United States Patent [19]

Kirkland

[11] **4,262,748**

[45] **Apr. 21, 1981**

[54] **REMOTE MULTIPLE STRING WELL COMPLETION**

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[73] Assignee: **Armco Inc.,** Middletown, Ohio

[21] Appl. No.: **67,733**

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[51] **Int. Cl.**[3] **E21B 23/00;** E21B 33/035

[52] **U.S. Cl.** ..... **166/348;** 166/75 A; 166/85; 166/313; 166/341; 285/25; 285/39; 285/137 A; 285/140

[58] **Field of Search** ..... 166/348, 341, 313, 315, 166/75 A, 85, 89, 237; 285/24, 25, 39, 137 A, 140

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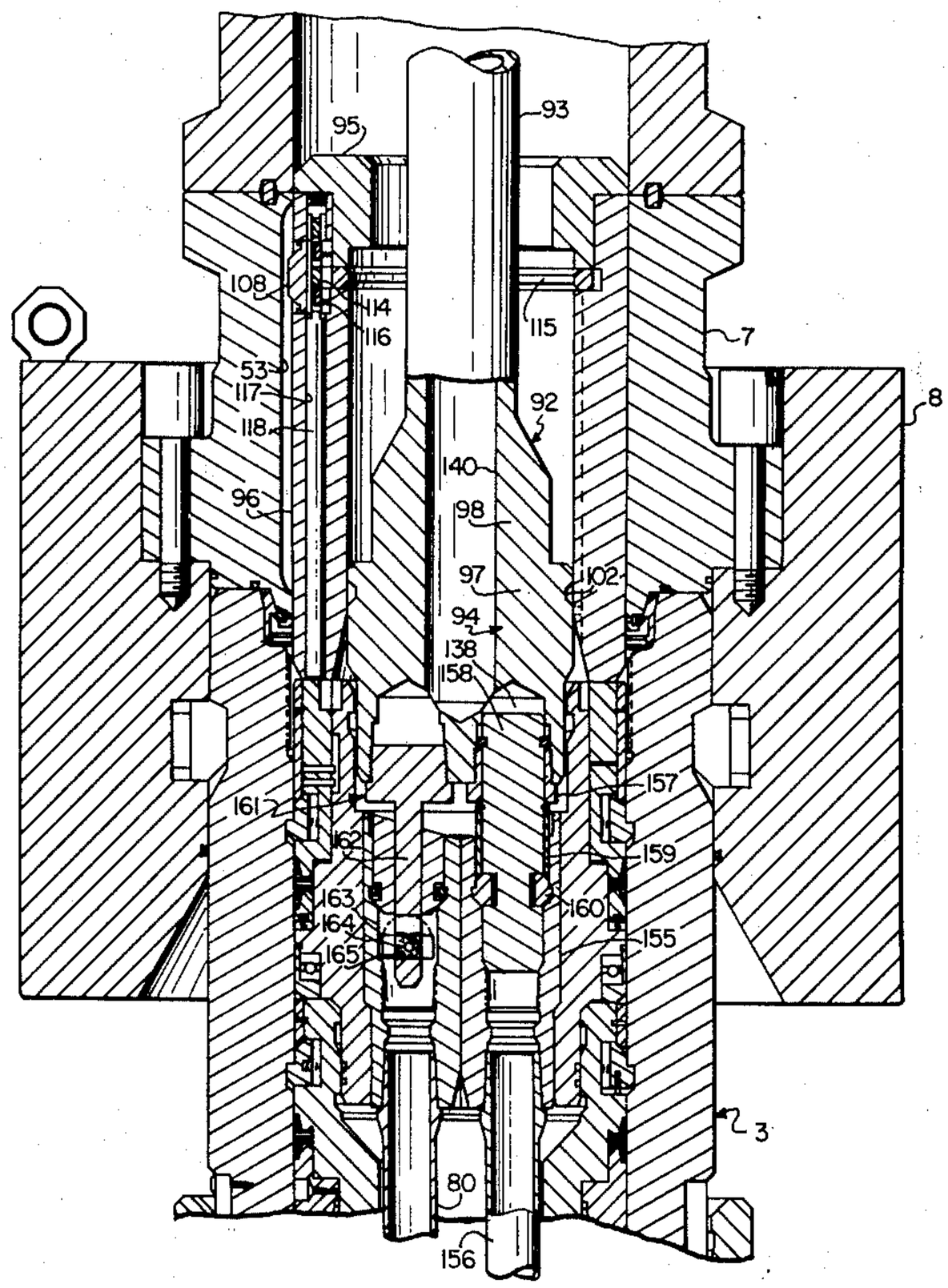
Primary Examiner—Stephen J. Novosad

Attorney, Agent, or Firm—Roylance, Abrams, Berdo & Farley

[57] **ABSTRACT**

Method and apparatus for multiple string well completions by remote operations in underwater installations, by which the tubing strings are installed independently rather than simultaneously.

16 Claims, 20 Drawing Figures



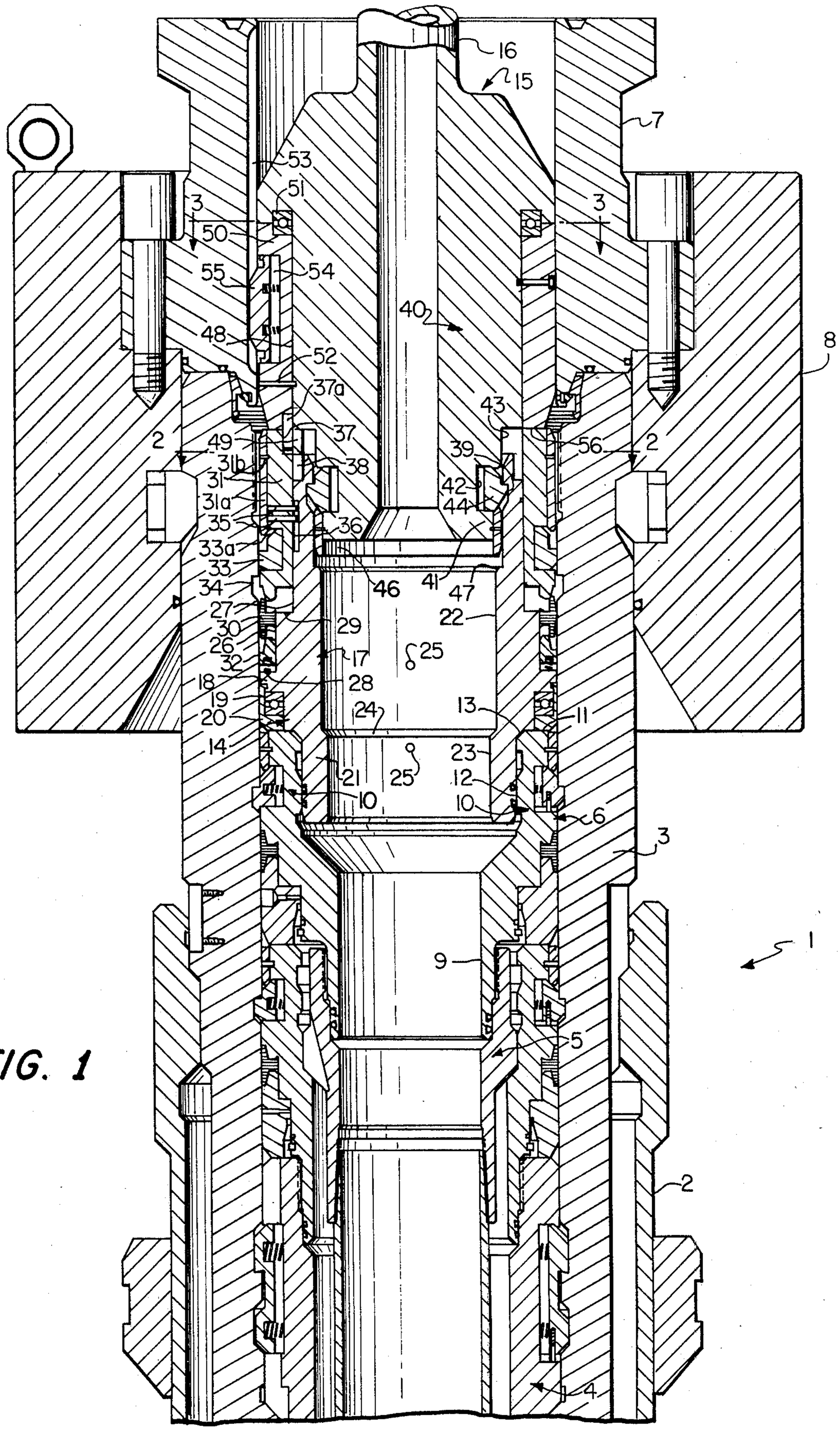

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FIG. 1

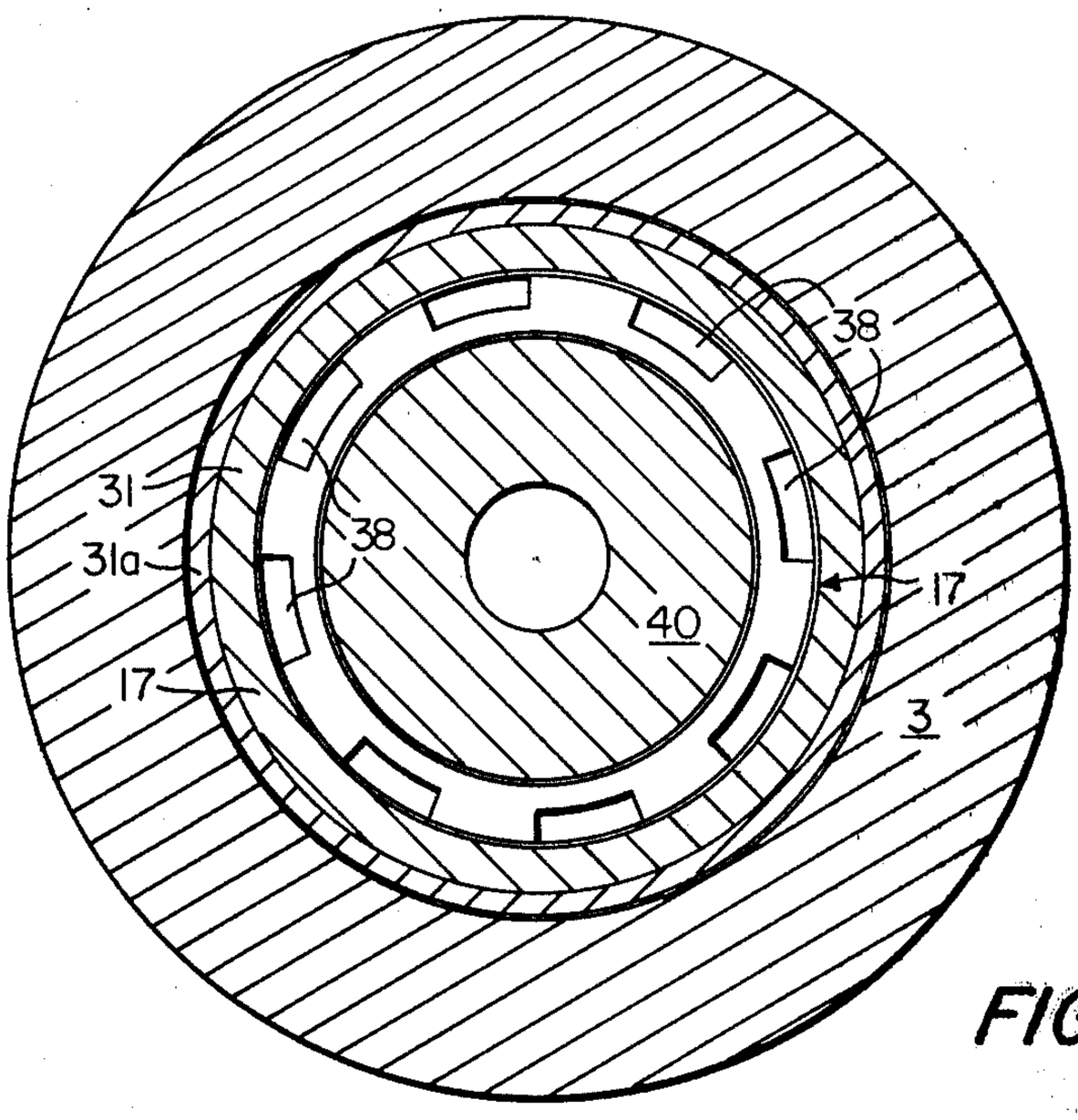

FIG. 2

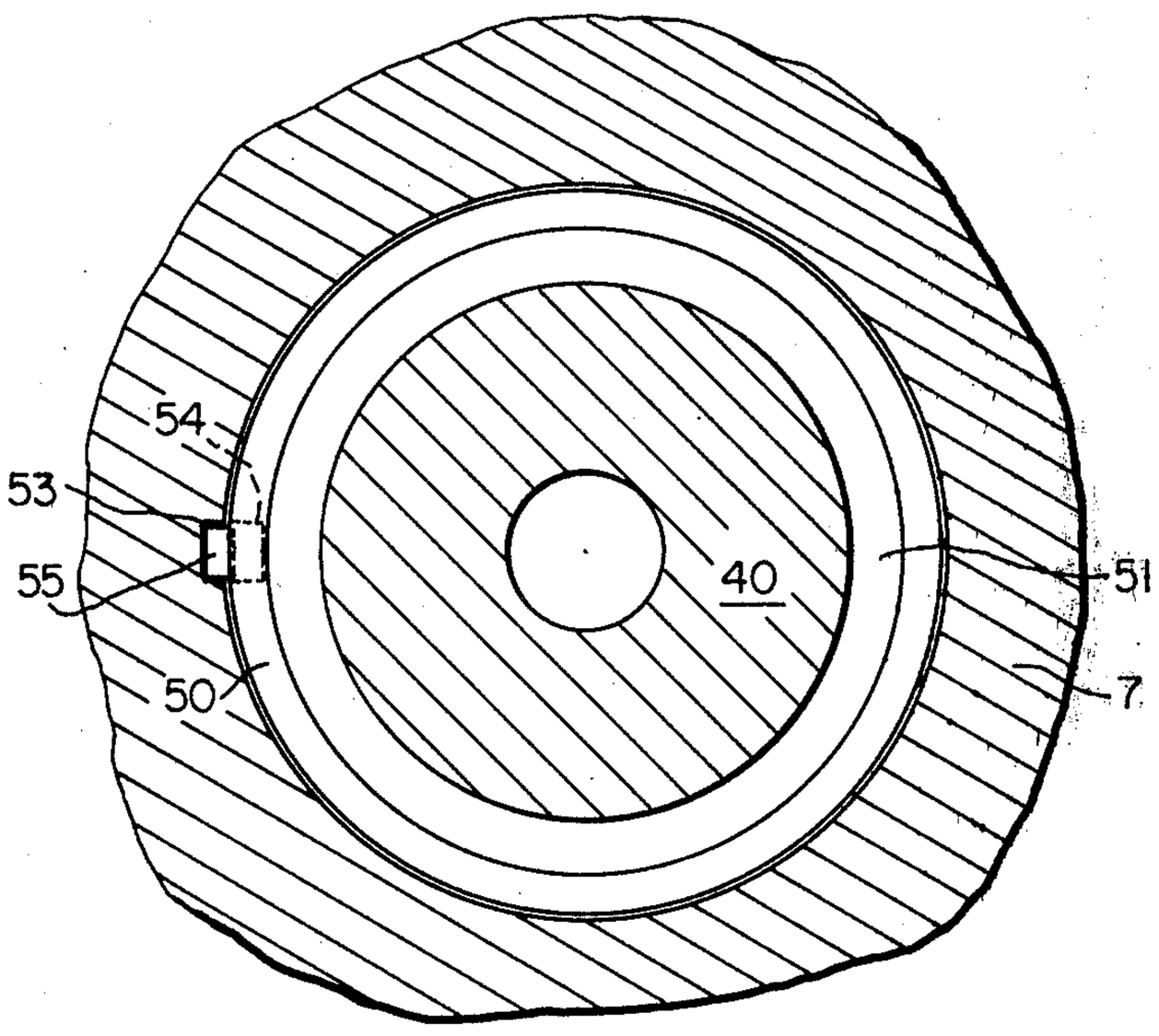

FIG. 3

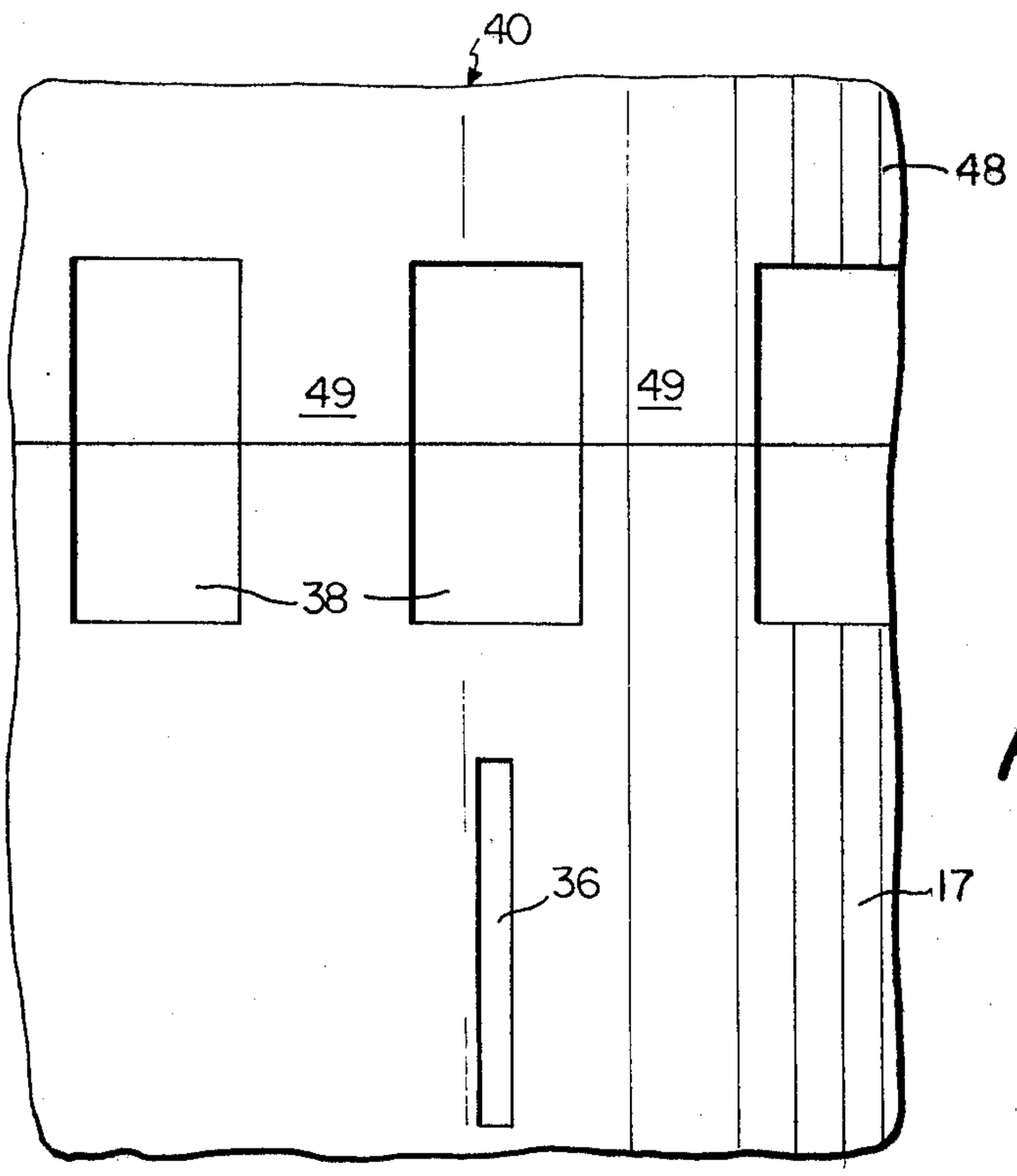

FIG. 4

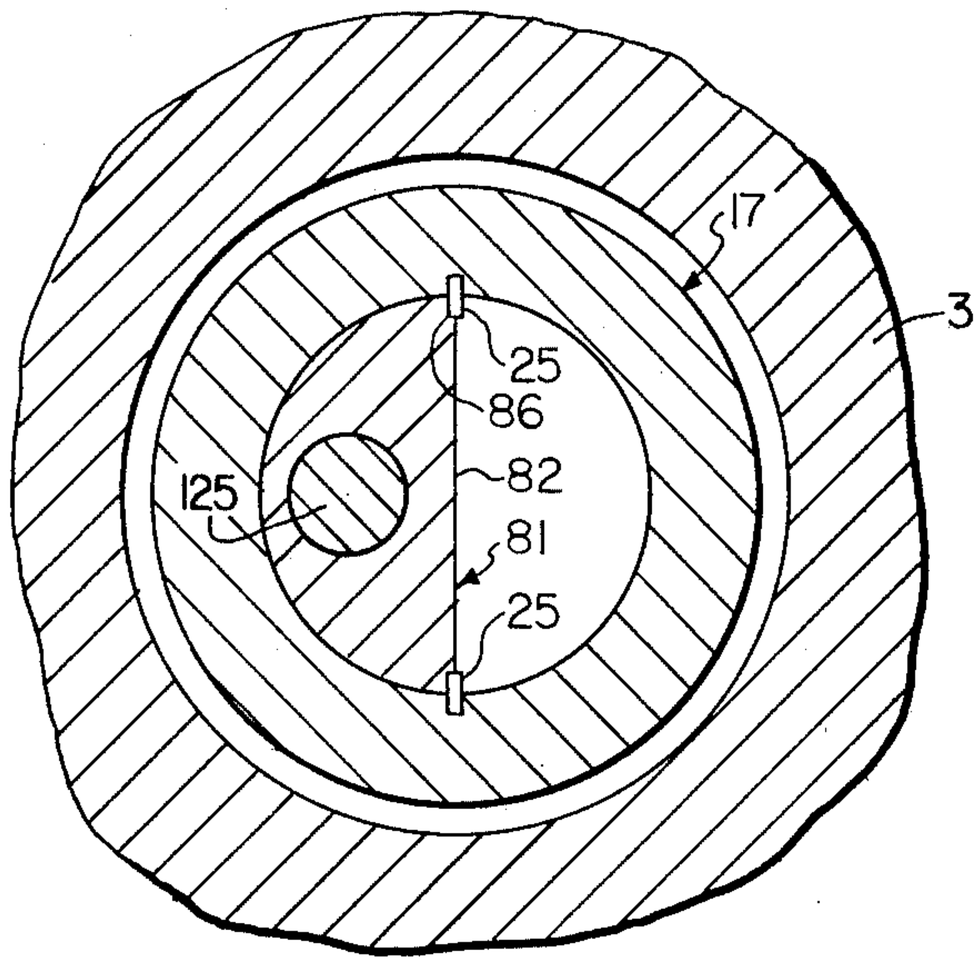

FIG. 12

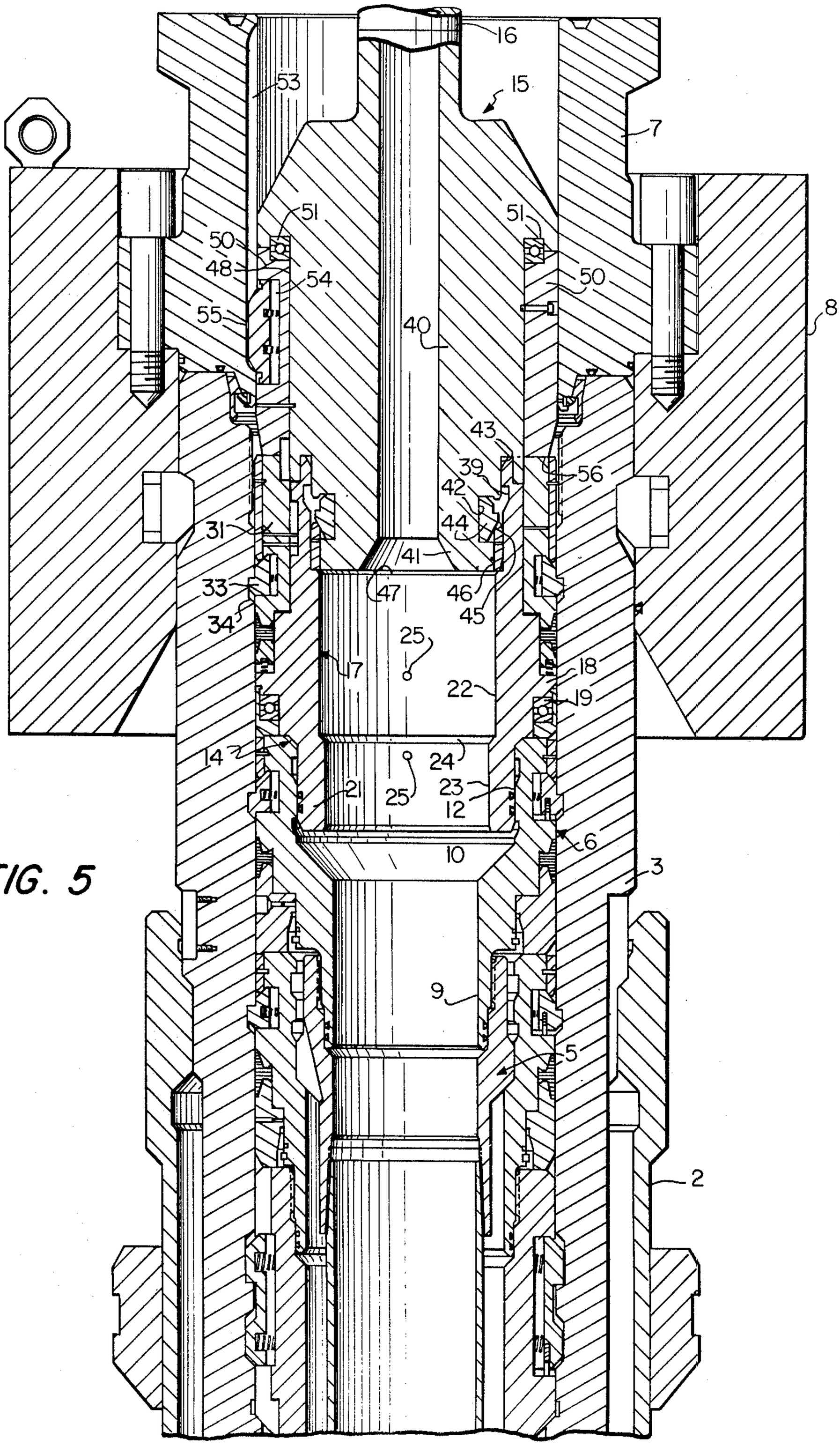
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FIG. 5

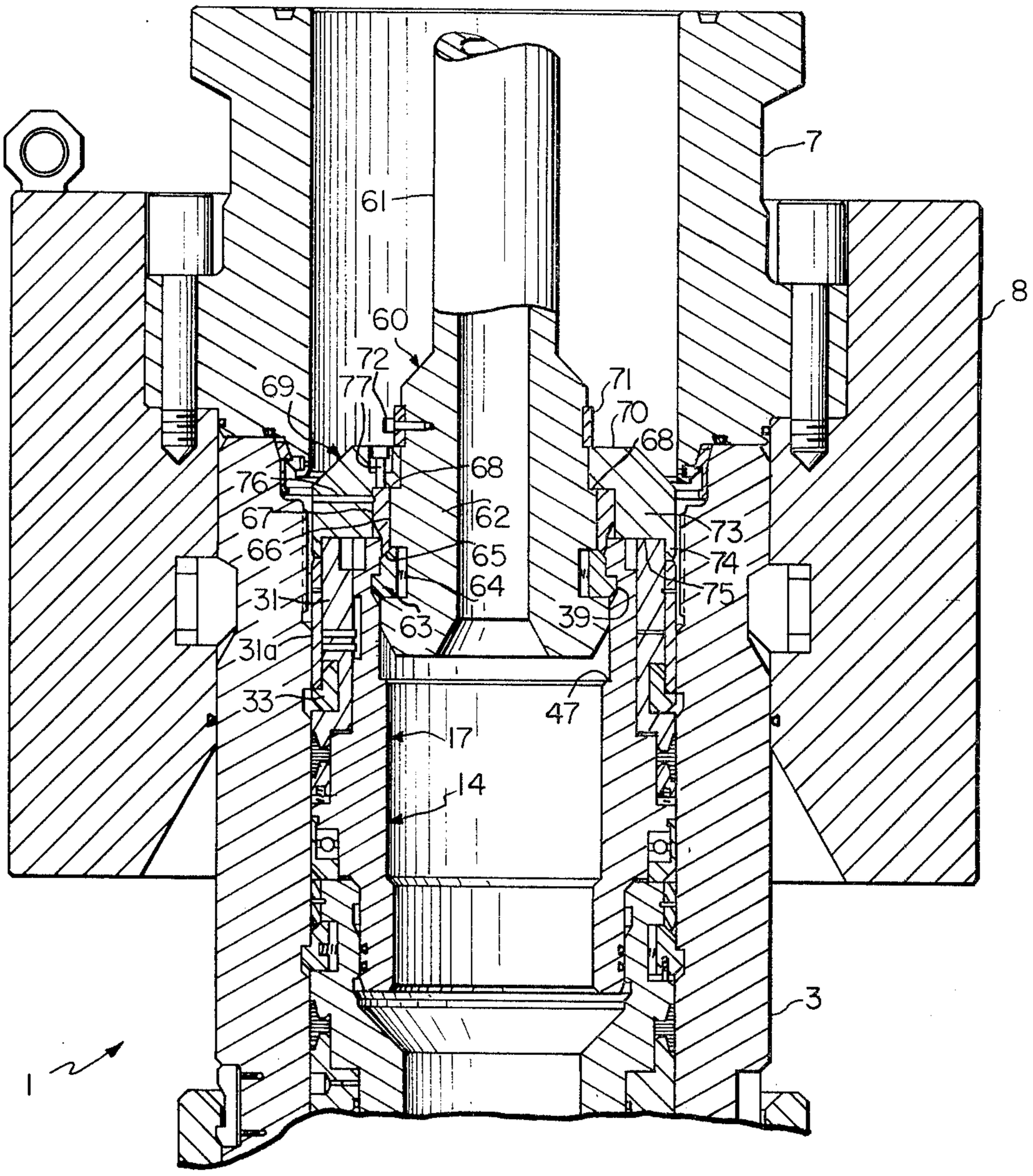
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FIG. 6

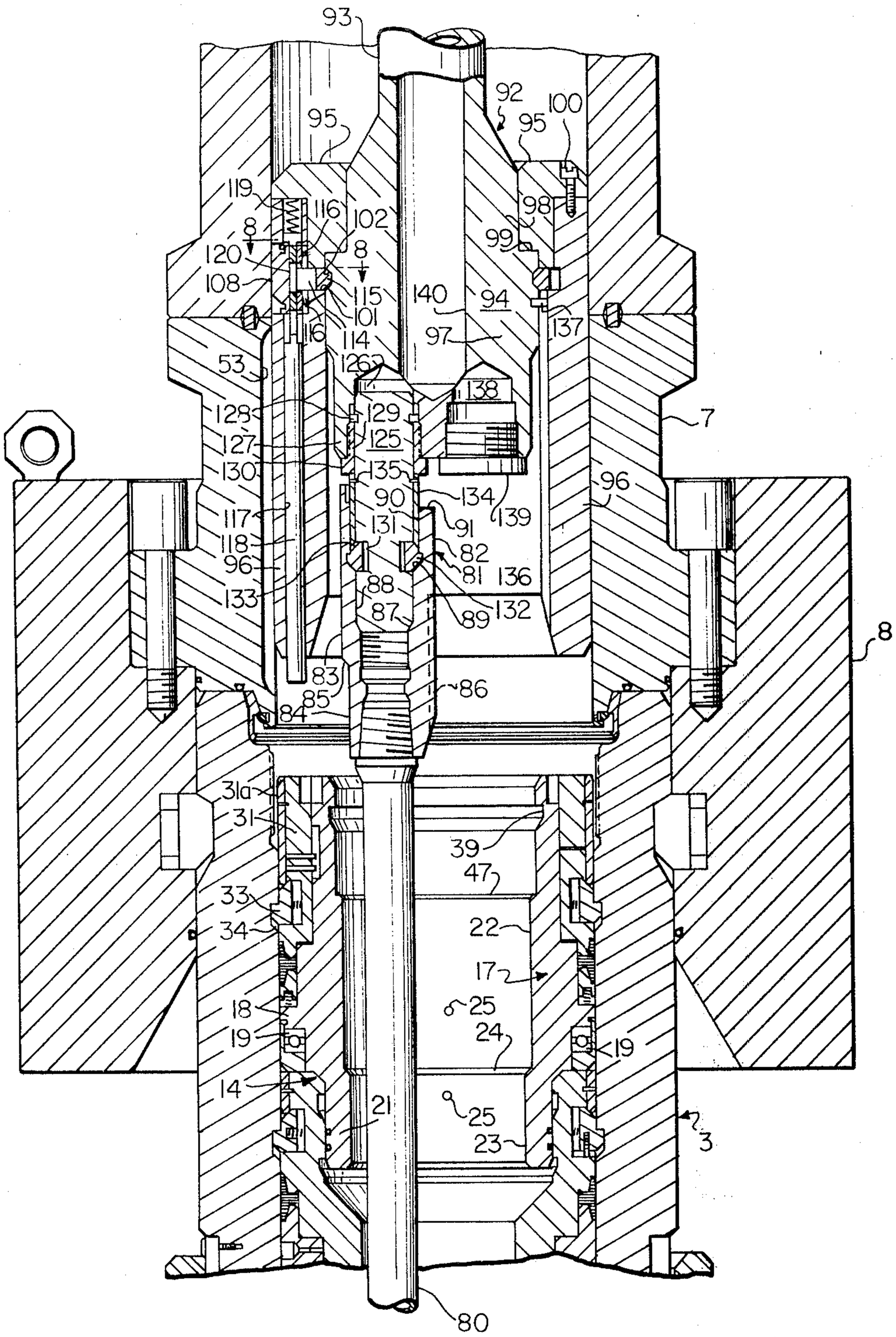
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FIG. 7

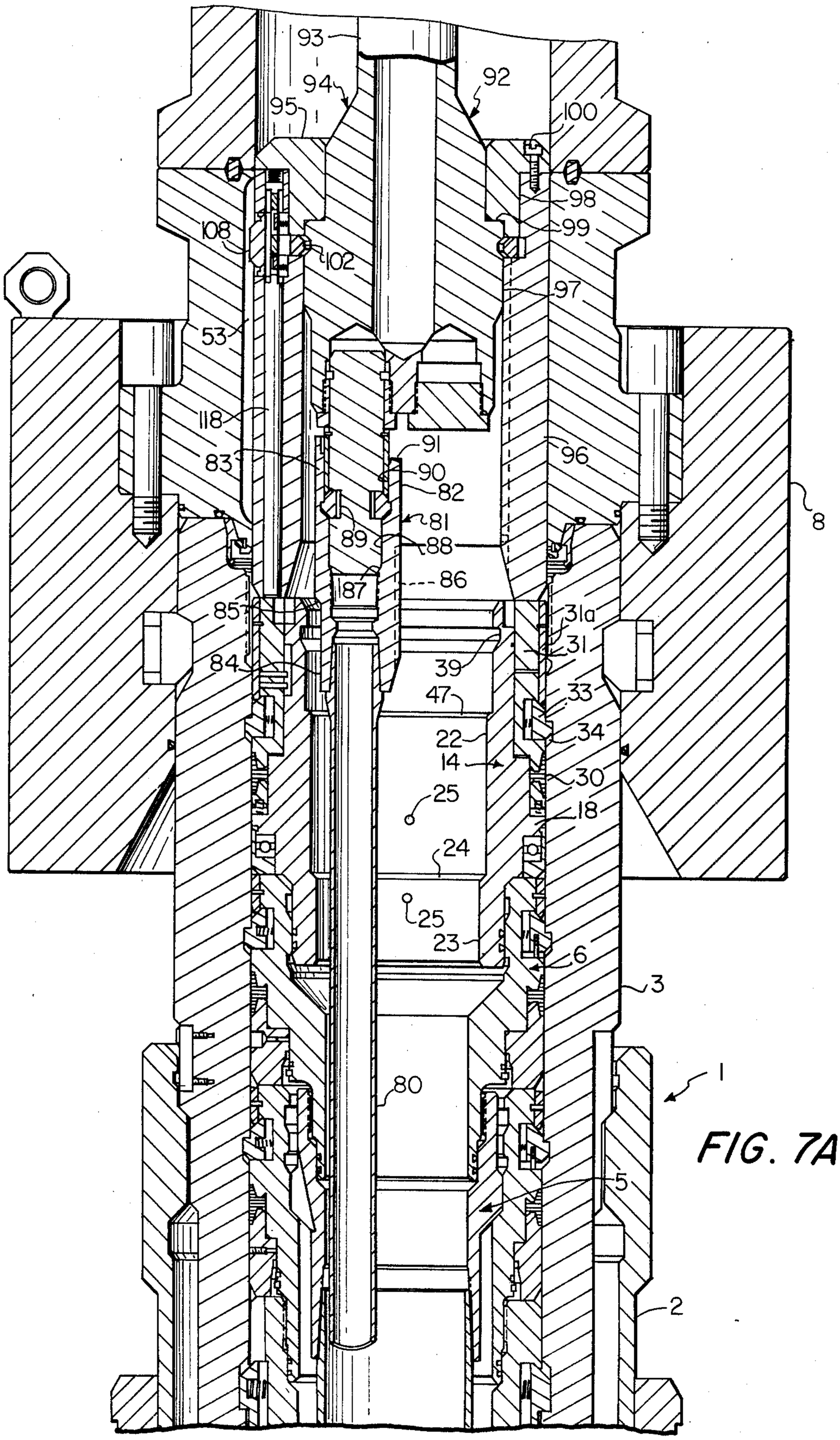
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FIG. 7A

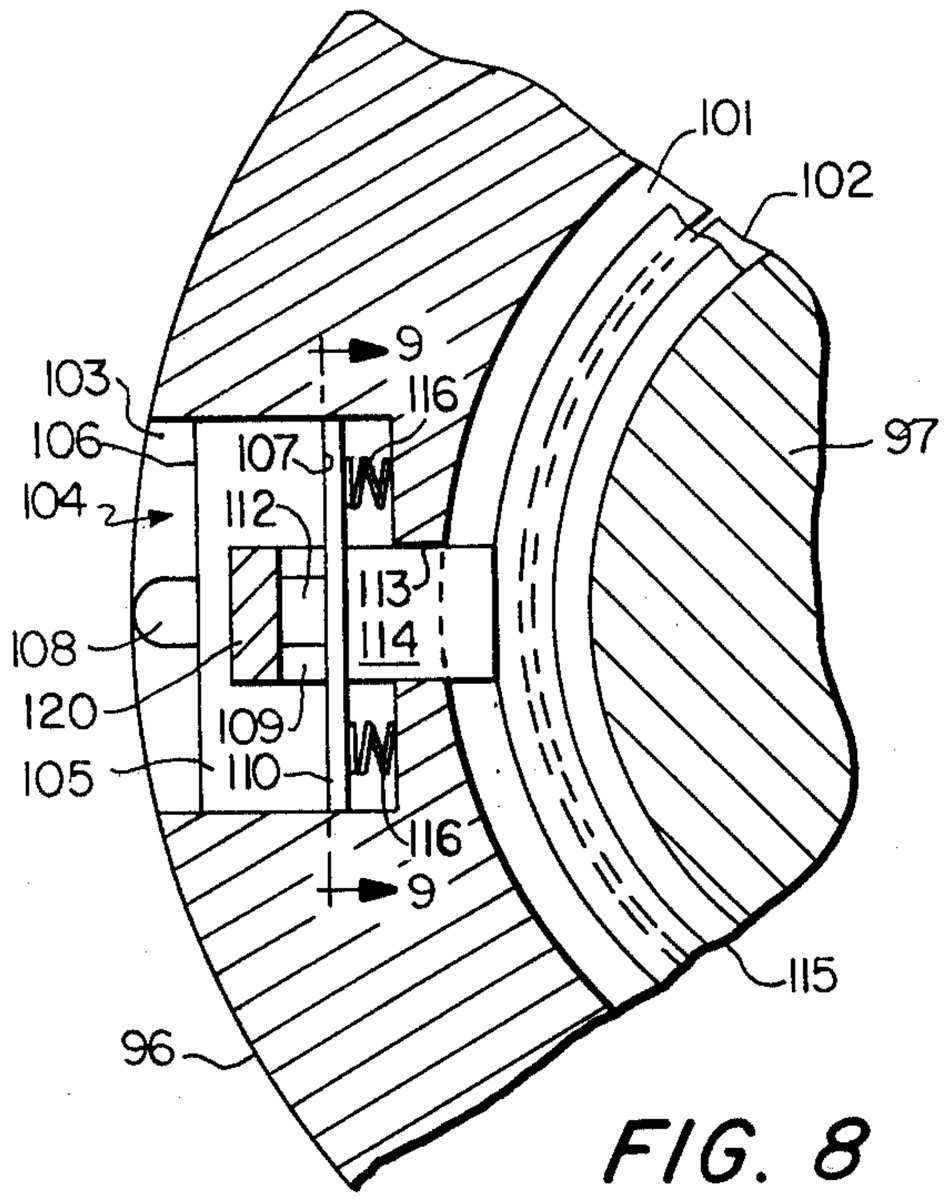

FIG. 8

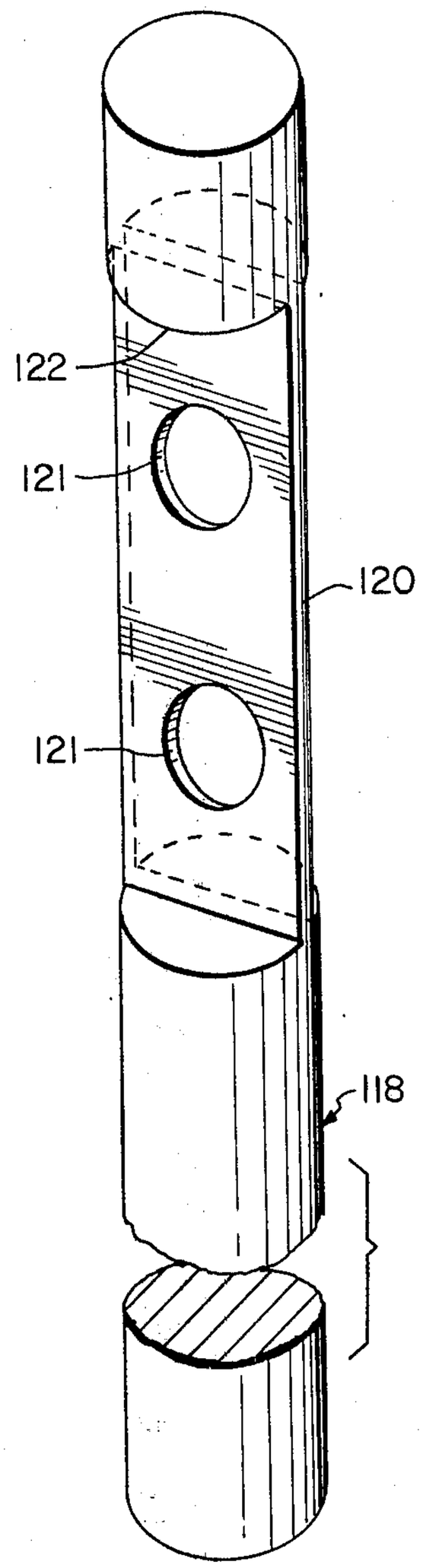

FIG. 10

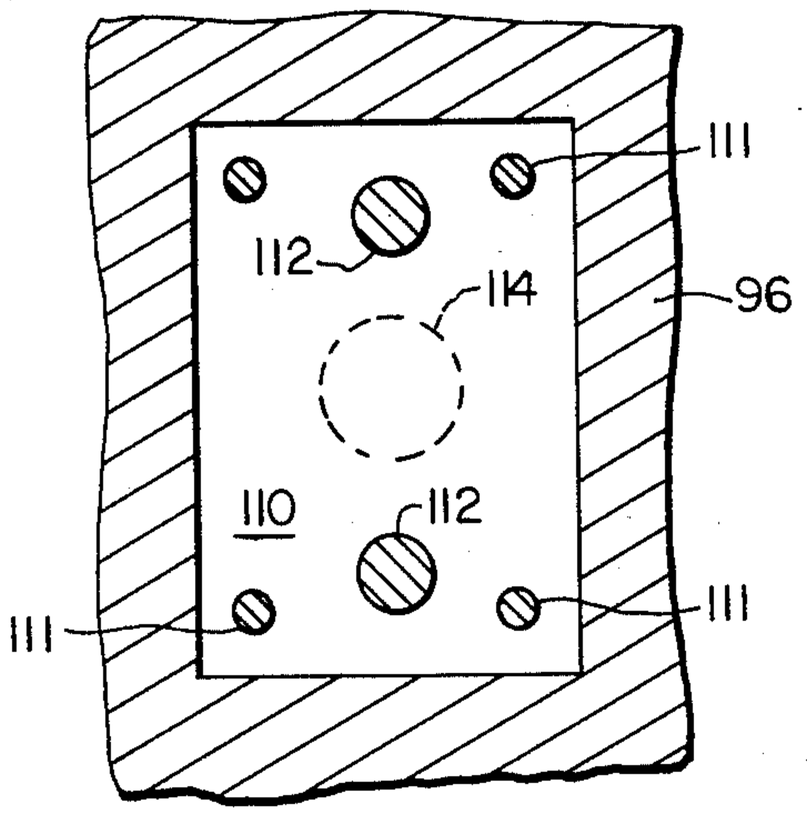

FIG. 9

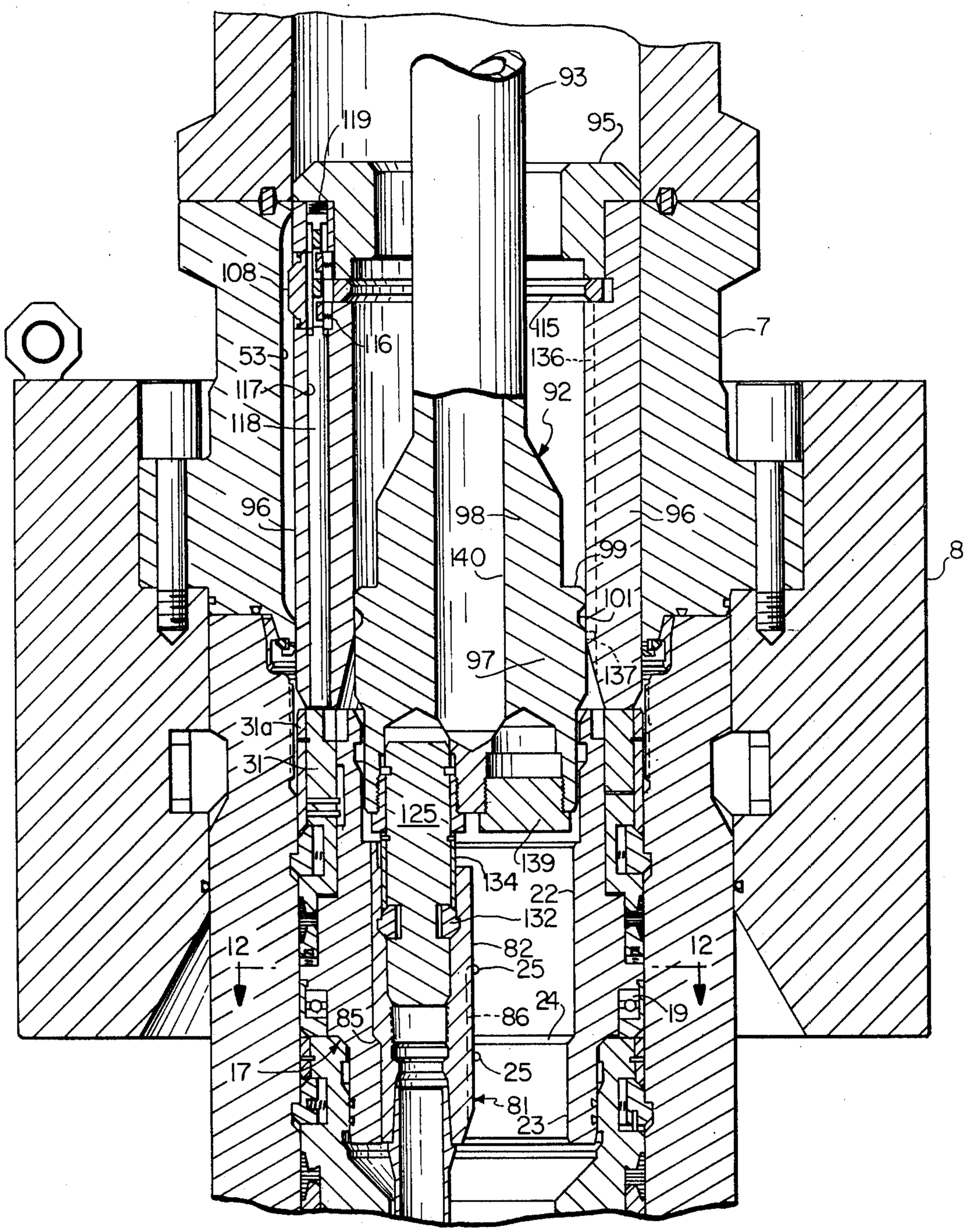
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FIG. 11

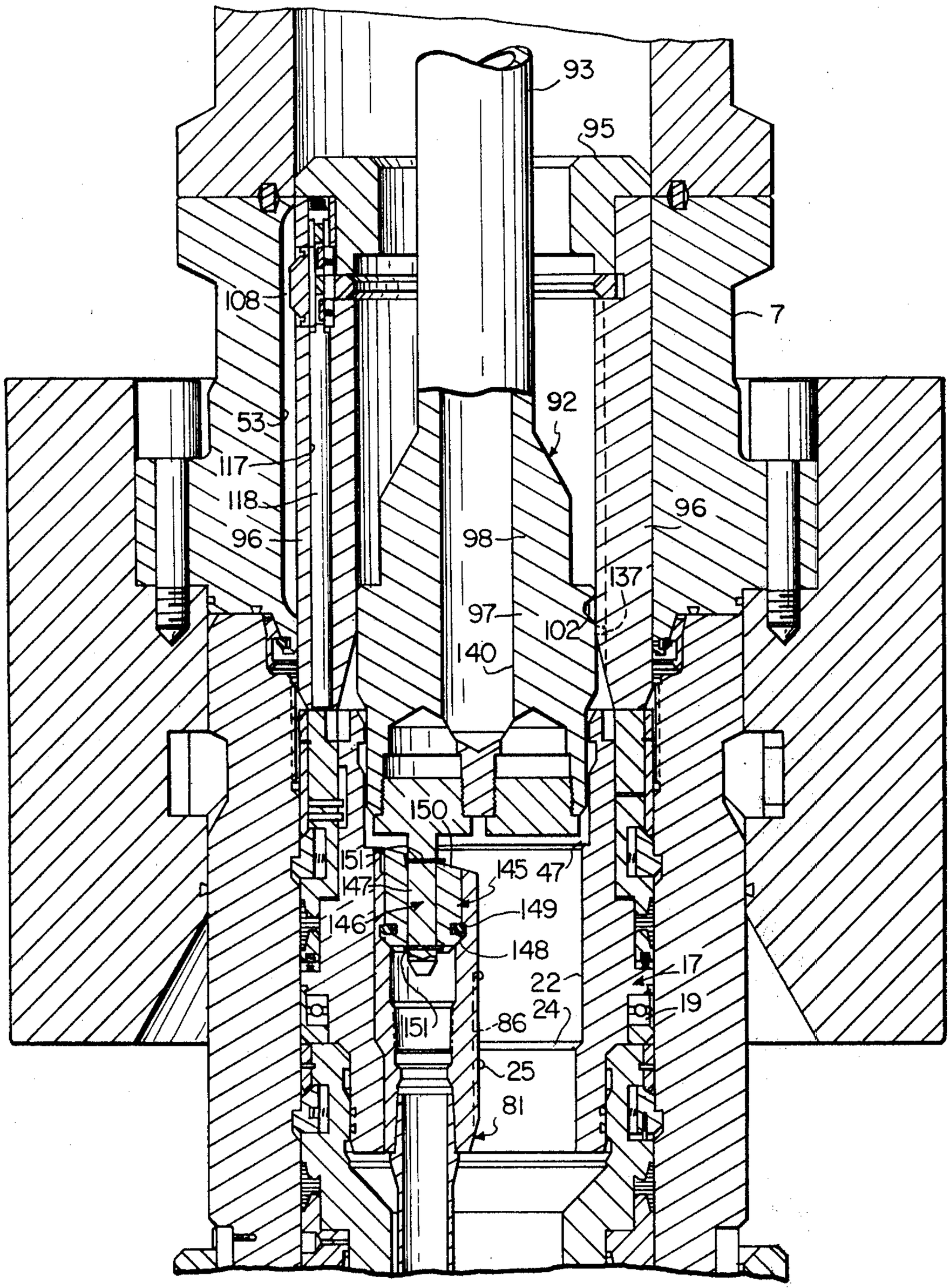
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FIG. 13

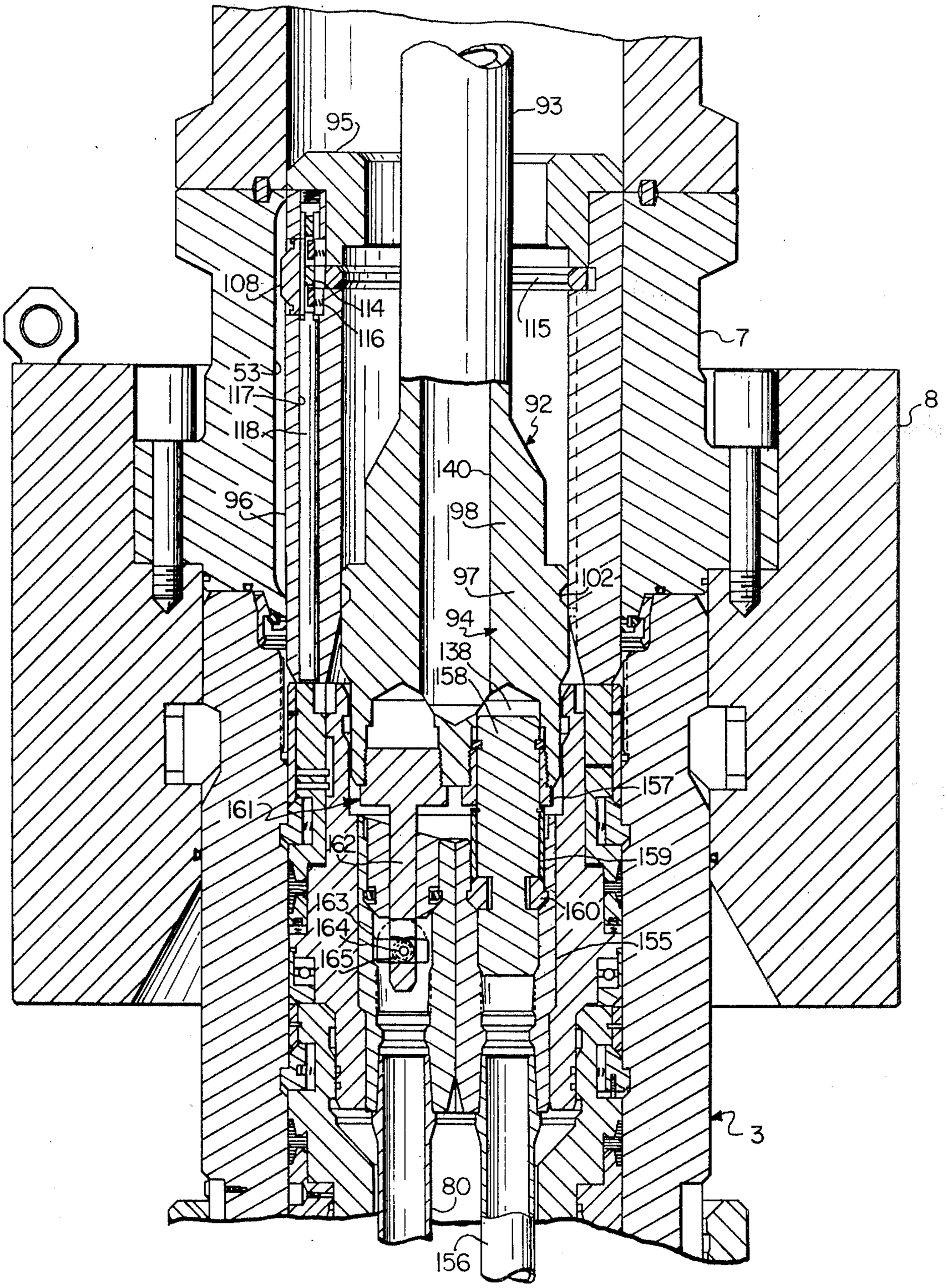
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FIG. 14

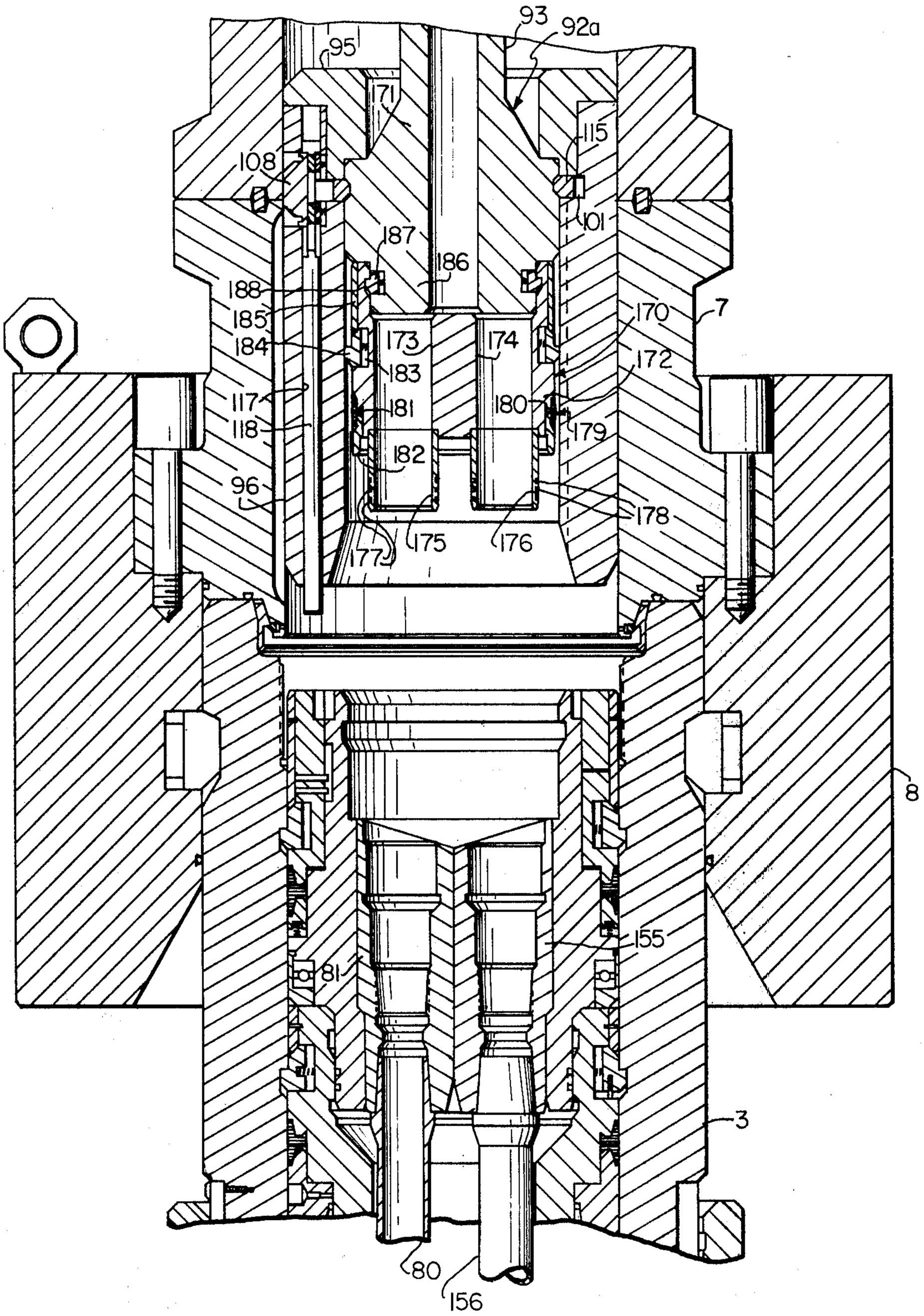
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FIG. 15

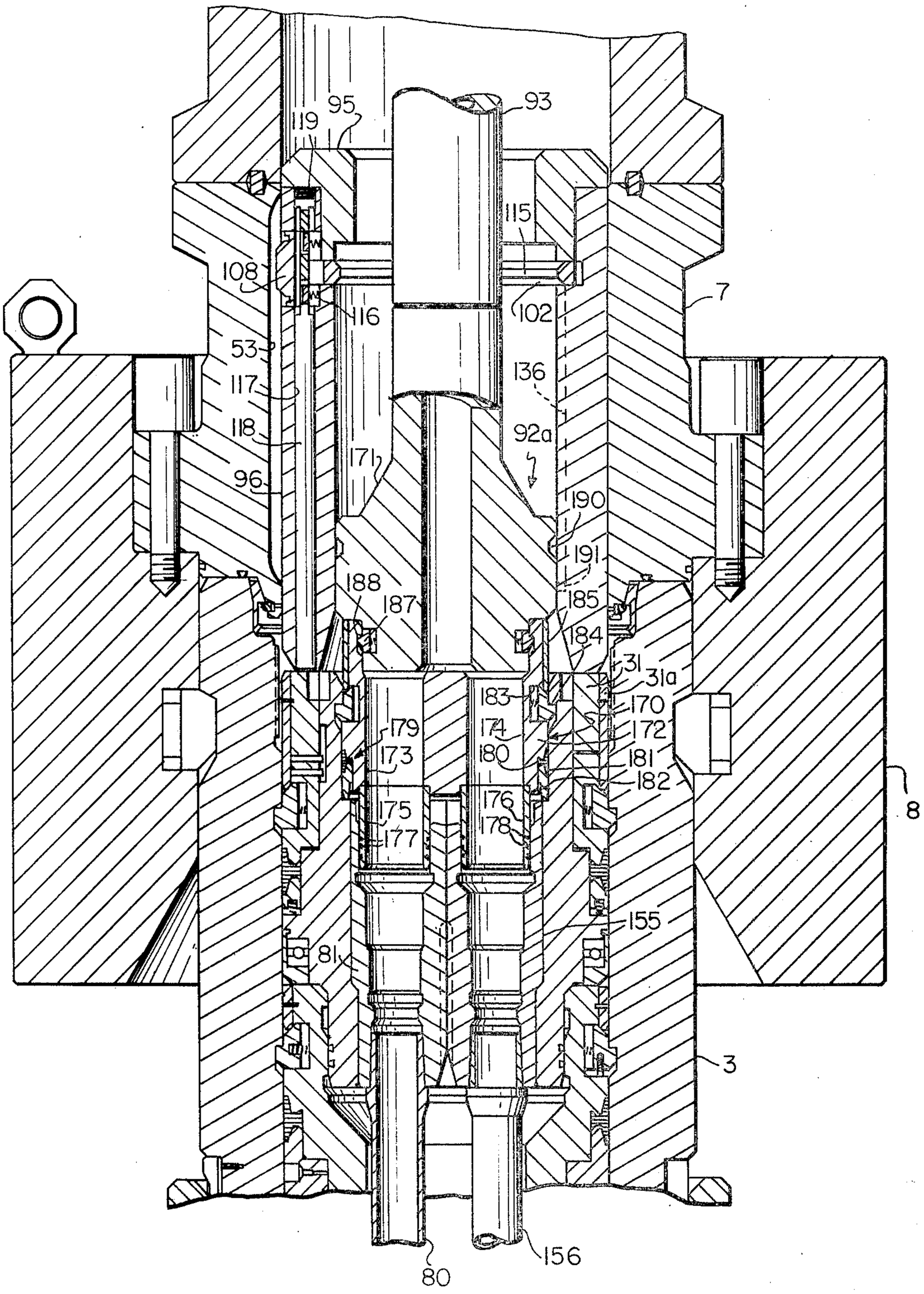
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FIG. 15A

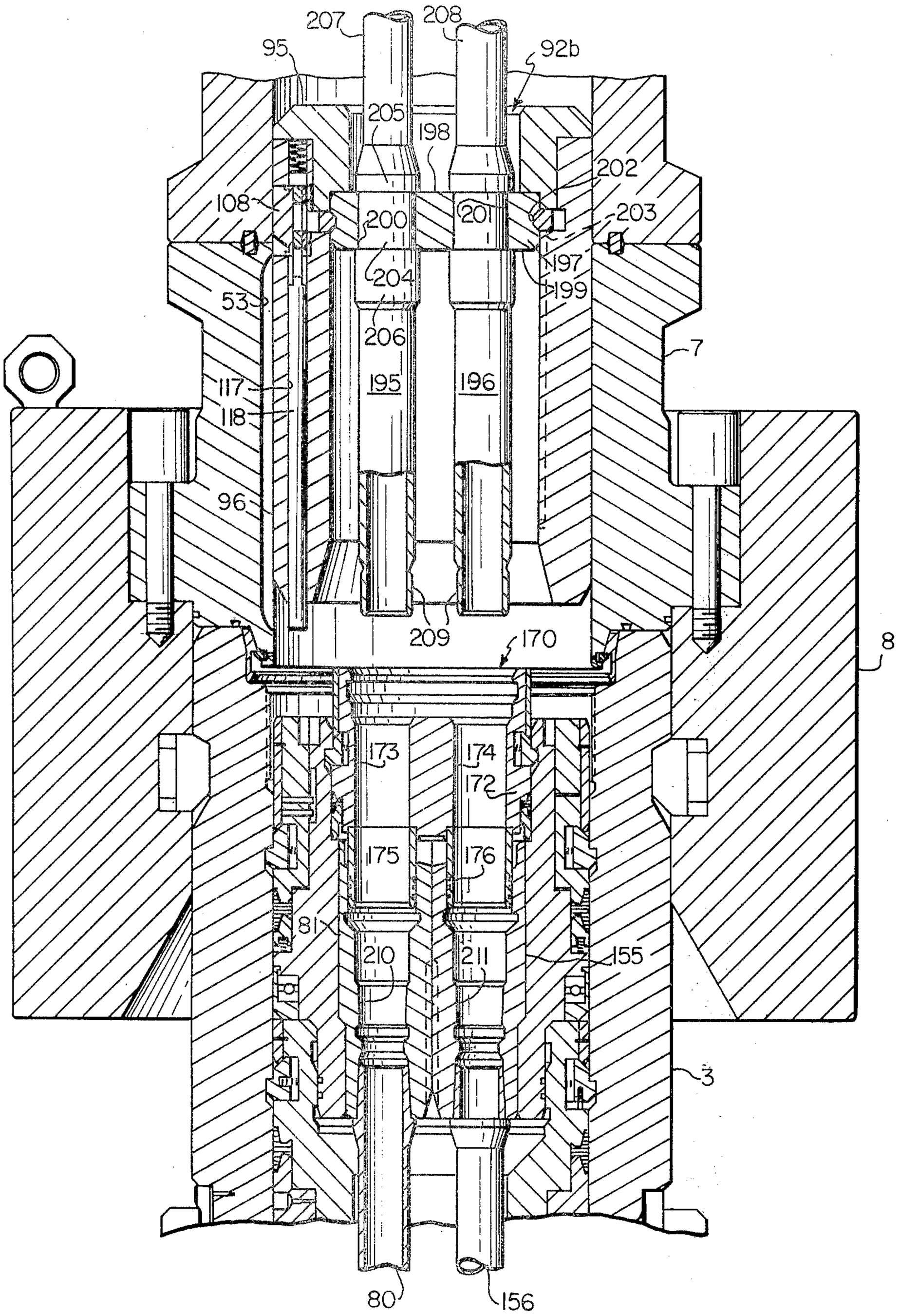
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FIG. 16

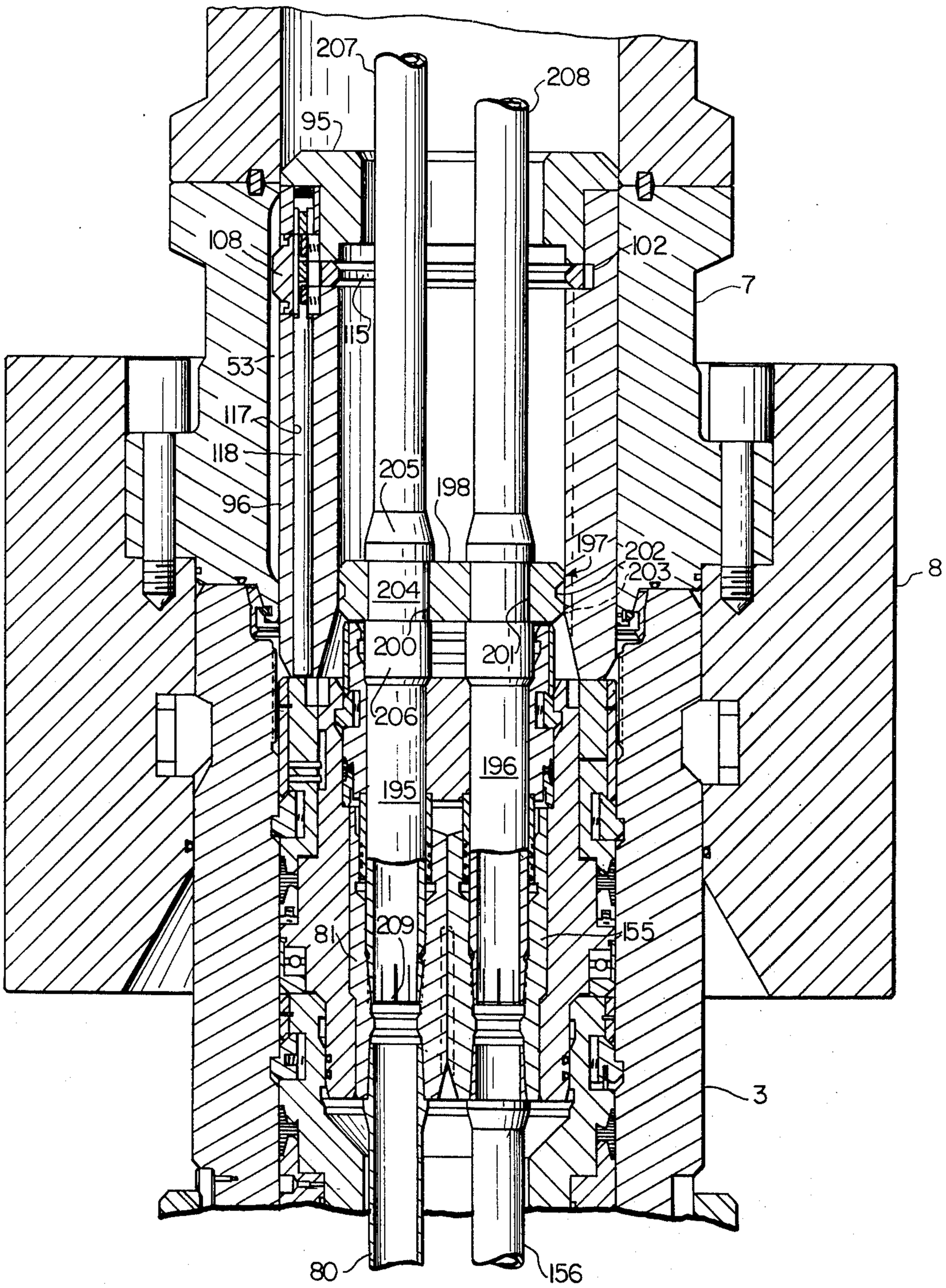
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FIG. 16A

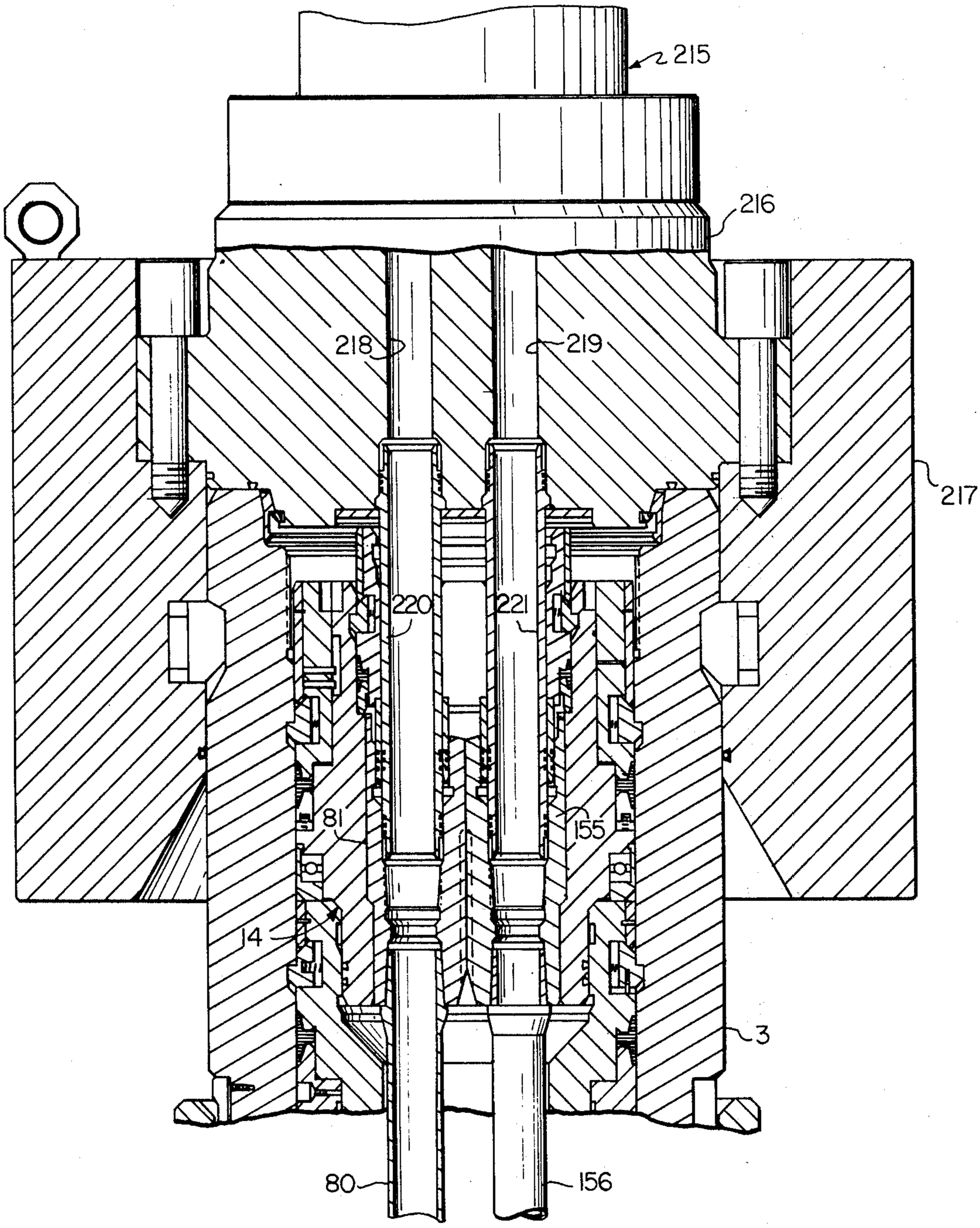

FIG. 17

REMOTE MULTIPLE STRING WELL COMPLETION

RELATED APPLICATION

Apparatus disclosed in this application is also disclosed and claimed in my copending application Ser. No. 067,745, filed concurrently herewith.

BACKGROUND OF THE INVENTION

When multiple string wells are installed on land, it is relatively simple to provide the option of running the tubing strings either simultaneously or individually, with so-called split tubing hangers being employed when the strings are run individually. For underwater installations, the tendency in the art has been to run the tubing strings simultaneously because of difficulties encountered in remote installation of split hangers. However, running multiple tubing strings simultaneously into a subsea or other underwater well installation requires expensive equipment on the platform or vessel which constitutes the operational base for handling the multiple strings and also presents severe problems in providing blowout preventers which will accommodate two or more tubes without crushing them. Accordingly, much effort has been expended in devising improved equipment for multiple string underwater wells, as seen for example in the following U.S. Pat. Nos.

3,603,401—Nelson et al
3,661,206—Putch et al
3,688,841—Baugh
3,693,714—Baugh
3,741,294—Morrill
3,800,869—Herd et al
3,807,497—Baugh
3,847,215—Herd

Despite extensive prior art effort and considerable success in the field, there has been a continuing need for improved methods and apparatus by which the tubing strings can be run individually into an underwater well, with simple and positive remote orientation of the split hangers, the capability of readily retrieving the hangers individually, fully independent running and retrieval of the tubing strings, improved sealing of the tubing hanger body, improved blowout protection and maximum running clearance at the wellhead for such things as gas lift valves.

OBJECTS OF THE INVENTION

A general object of the invention is to provide a method and apparatus by which multiple tubing strings can be run into an underwater well installation independently rather than simultaneously.

Another object is to provide such a method and apparatus in which a multiple string hanger body is landed independently in oriented position and the tubing strings are then installed independently using the same orienting means employed to orient the hanger body.

A further object is to provide for improved sealing of the hanger body in the wellhead.

Yet another object is to provide such a method and apparatus which depends only upon relatively simple mechanical devices for all of the operations involved.

SUMMARY OF THE INVENTION

According to the invention, a multiple string tubing hanger body or bushing is secured to a handling tool,

with a known orientation of the body on the tool, the tool is then manipulated by a handling string to land the hanger body in a wellhead body, and the combination of the tool and the hanger body is then rotated relative to the wellhead body until a locator key on the tool snaps into a locator groove on the wellhead body so that the hanger body has a known rotational orientation in the wellhead. By combined rotation of the handling tool relative to the hanger body and downward movement of the tool relative to the hanger body, a packer is then set mechanically to seal between the hanger body and the wellhead body, and latch members are actuated, by the same motion used to set the packer, to latch the hanger body in place. At this stage, after the handling tool has been removed, the hanger body can be retrieved by a simple retrieval operation, if required. The first tubing string and its individual hanger segment are then installed by use of a tool which allows orientation of the hanger segment to be accomplished using the same locator groove in the wellhead body which was employed to orient the hanger body or bushing. During orientation of the tubing string and its hanger segment, the hanger segment is retained in an elevated position, above its intended landed position, the hanger segment being released for landing only after orientation has occurred. Landing of the hanger segment automatically releases the handling tool from the segment so the tool and handling string can be retrieved. Using the same handling tool employed to install the first tubing string, a deflector plug is now installed in the hanger segment of that string, and the handling tool is again retrieved. Still using the same tool, the second tubing string and its hanger segment are installed, with orientation again occurring before the segment is landed. Using the same handling tool but with a different main body substituted therein, a tubing hanger packoff unit is now installed, with orientation of the packoff unit being achieved before that unit is landed. If necessary, the packoff unit can be retrieved at this stage, using a simple tool which does not require orientation. A circulation tool is now installed, again using the same handling tool but with another main body substituted therein. Again, orientation of the circulation tool is first accomplished and the circulation tool is then released and landed. The wellhead upper body is then removed and the Christmas tree installed conventionally, using the guide posts of the permanent guide base for orientation.

IDENTIFICATION OF THE DRAWINGS

In order that the manner in which the foregoing and other objects are achieved according to the invention can be understood in detail, one particularly advantageous apparatus embodiment of the invention, and the method as practiced therewith, will be described with reference to the accompanying drawings, which form part of the original disclosure of this application, and wherein:

FIG. **1** is a vertical axial cross-sectional view showing installation of a multiple string tubing hanger body in an upper wellhead body of an underwater installation;

FIGS. **2** and **3** are transverse cross-sectional views taken generally on lines **2—2** and **3—3**, FIG. **1**;

FIG. **4** is a fragmentary side elevational view of a portion of the apparatus of FIG. **1**;

FIG. **5** is a view similar to FIG. **1** but with the packer between the hanger body and the wellhead body energized;

FIG. 6 is a vertical sectional view of a portion of the apparatus of FIGS. 1–5 illustrating the manner in which the hanger body can be retrieved;

FIG. 7 is a view similar to FIG. 1 illustrating installation of a first tubing string and tubing hanger segment with the combination of the segment and its handling tool about to enter the wellhead upper body;

FIG. 7A is a view similar to FIG. 7, showing the parts after rotational orientation of the handling tool relative to the wellhead upper body has been accomplished;

FIG. 8 is a fragmentary transverse sectional view taken generally on line 8—8, FIG. 7;

FIG. 9 is a vertical sectional view taken generally on line 9—9, FIG. 8;

FIG. 10 is a fragmentary perspective view of a latch rod employed in the handling tool employed for accomplishing the installation illustrated in FIG. 7;

FIG. 11 is a view similar to FIG. 7 showing the tubing hanger segment and its handling tool after landing of the segment in the hanger body;

FIG. 12 is a horizontal sectional view taken generally on line 12—12, FIG. 11, after removal of the handling tool;

FIG. 13 is a view similar to FIG. 7 illustrating the landing of a deflector plug in the tubing hanger segment;

FIG. 14 is a view similar to FIG. 7 showing a landed second tubing hanger segment before removal of the handling tool;

FIGS. 15 and 15A are views similar to FIGS. 7 and 11, respectively, illustrating installation of a tubing hanger packoff device according to the invention;

FIGS. 16 and 16A are views similar to FIGS. 7 and 11, respectively, illustrating installation of circulation stingers according to the invention; and

FIG. 17 is a view similar to FIG. 7 showing a Christmas tree installed to complete the well installation.

DETAILED DESCRIPTION OF APPARATUS

In order that the method can be readily understood, one apparatus embodiment of the invention will first be described for each stage of the complete method.

Hanger Body, Packer And Handling Tool

Referring first to FIGS. 1–4, the invention is illustrated as applied to remote installation of two tubing strings in a well including an underwater wellhead indicated generally at 1 comprising surface casing 2, a wellhead body 3 installed in the surface casing, casing hangers 4 and 5 supported in body 3 and each supporting a string of casing, a mandrel packing unit 6, a wellhead upper body 7, and a remotely operated connector 8 securing upper body 7 to the top of body 3. Connector 8 can be of any suitable conventional type, such as that shown in U.S. Pat. No. 3,228,715 to Neilon et al. Body 7 is equipped with guide arms (not shown) to cooperate with the guide posts of the usual primary guide system (not shown) so that, when landed and secured by connector 8 to body 3, body 7 is in a known rotational position relative to the guide posts. Packing unit 6 has a main body including a lower portion 9, having an inner diameter equal to that of the string of casing suspended from hanger 5, and an upper portion 10 which is of substantially larger internal diameter. Upper portion 10 presents a flat transverse annular upper end face 11, a right cylindrical inner surface 12, and a downwardly and inwardly tapering frusto-conical shoulder 13 which joins face 11 and surface 12.

Preparatory to installation of the tubing strings, a tubing hanger body or bushing 14 is installed by use of a handling tool 15 manipulated by the usual handing string 16. Hanger body 14 comprises a tubular main body 17 having an intermediate portion 18 of outer diameter such as to fill the bore of wellhead body 3. Below portion 18, the outer diameter of body 17 is reduced to accommodate an antifriction thrust bearing 19, which can be a conventional ball bearing or roller bearing disposed between a spacer ring 20 and the downwardly facing shoulder presented by intermediate portion 18. Lower end portion 21 of body 17 is of further reduced outer diameter so as to be slidably received by the inner wall 12 of the upper portion of casing hanger 6. When hanger body 14 is fully landed, it is supported via bearing 19 on the upper end face 11 of casing hanger 6.

The bore of body 17 is cylindrical, including an upper portion 22 of larger diameter, a lower portion 23 of smaller diameter, and an intermediate transverse annular upwardly facing shoulder 24. Two vertically aligned orienting pins 25 project radially inwardly from the wall of the bore of body 17, one above and one below shoulder 24, for a purpose later described.

Above intermediate portion 18, body 17 has a first portion 26 of reduced outer diameter and, thereabove, a second portion 27 of still smaller outer diameter so that a first transverse annular upwardly facing shoulder 28 is provided between portions 18 and 26, and a second such shoulder 29 is provided between portions 26 and 27. Portions 26 and 27 accommodate a seal unit comprising an elastomeric packing ring 30, disposed between an actuator sleeve 31 and a compression ring 32, ring 32 being adjacent shoulder 28 and sleeve 31 slidably embracing portion 27 of body 17. Sleeve 31 has an outwardly opening transverse groove which accommodates latch segments 33, the segments being spring biased outwardly for engagement in a transverse annular inwardly opening groove 34 in wellhead body 3. Segments 33 have upwardly and inwardly slanting camming surfaces 33*a* which are exposed upwardly when the segments are engaged in groove 34. An actuator sleeve 31*a* slidably embraces sleeve 31 above segments 33 and is initially fixed to sleeve 31 by shear pins at 31*b*.

Sleeve 31 is provided with two orienting pins 35 which project radially inwardly from the sleeve into slidable engagement in a vertical external slot 36 in the upper end portion of body 17. A key slot 37 opens upwardly at the upper end of sleeve 31. Thus, if the rotational position of key slot 37 is predetermined, the rotational location of orienting pins 25 will likewise be predetermined. The upper end of body 17 is provided with a circumferentially spaced series of upwardly opening notches 38.

Hanger body 14 is mounted on handling tool 15 before running the combination of the tool and hanger body. The upper end portion of body 17 is provided with a transverse annular inwardly opening groove 39. Tool 15 includes a main body 40 having a lower end portion 41 of smaller outer diameter, a transverse annular outwardly opening groove 42 at the upper end of portion 41, and a portion 43 located immediately above groove 42 and having an outer diameter such as to be slidably embraced by the inner surface of the portion of body 17 above groove 39. A plurality of latch segments 44 are disposed in groove 42 and urged outwardly by

springs (not shown), segments **44** having lower camming faces **45** which slant downwardly and inwardly. Secured to body **40** by shear pins, an actuating ring **46** slidably embraces lower end portion **41** of body **40** and projects therebelow. Ring **46** is in turn slidably embraced by the upper end portion of body **17** which is of slightly enlarged inner diameter so as to present a transverse annular upwardly directed shoulder **47** against which ring **46** can be driven, as later described, to retract segments **44**.

Above portion **43**, body **40** has a larger diameter portion **48**, and at the juncture between portions **48** and **43**, portion **48** is provided with a plurality of downwardly projecting circumferentially spaced lugs **49** dimensioned and shaped to be accommodated respectively by notches **38** on body **17**. Notches **38** are rectangular, mutually identical and equally spaced. Lugs **49** are likewise rectangular and equally spaced. When hanger body **14** is mounted on handling tool **15**, the rotational position of body **17** relative to body **40** is such that lugs **49** are aligned with the spaces between notches **38**, the lower edges of the lugs thus engaging portions of the upper end face of body **17**.

The outer right cylindrical surface of portion **48** of body **40** is slidably embraced by a sleeve **50** having an outer diameter such as to be slidably embraced by the wall of the bore of wellhead upper body **7**. The upper end portion of body **40** is enlarged to project outwardly over the upper end of sleeve **50**, and an antifriction thrust bearing **51**, such as a ball bearing or a roller bearing, is interposed between the upper end of the sleeve and the enlarged upper end portion of body **40**. Sleeve **50** is initially fixed releasably to body **40**, as by shear pins **52**.

Wallhead upper body **7** is provided with a vertical inwardly opening locator groove **53**, FIGS. **1** and **3**, and, since body **7** is landed conventionally in a known position relative to the guide posts of the usual permanent guide base (not shown), the orientation of groove **53** is predetermined with reference to the permanent guide base. Sleeve **50** has a vertical outwardly opening slot **54** which accommodates a locator key **55** urged outwardly by springs as shown. Lower end face **56** of sleeve **50** is dimensioned for flush engagement with the upper end face of sleeve **31** and is provided with a downwardly projecting key **37***a*, FIG. **1**, which cooperates with the upwardly opening locator slot **37** of sleeve **31**.

When the combination of hanger body **14** and handling tool **15** is run in, spacer ring **20** of bearing **19** lands on upper end face **11** of mandrel packing unit **6**, allowing the combination of hanger body **14** and tool **15** to be rotated, by manipulation of handling string **16**, until locator key **55** on sleeve **50** snaps into locator groove **53** in wellhead upper body **7**. Since sleeve **50** is rotationally fixed on sleeve **31** by key **37**, and sleeve **31** is in turn rotationally fixed on body **17** of the hanger by pins **35**, engagement of key **55** in groove **53** establishes a given rotational orientation of the orienting pins **25** of the hanger body with reference to wellhead upper body **7**.

With key **55** engaged in groove **53**, further rotation of the handling string shears the pins **52**, freeing tool body **40** for rotation relative to the combination of sleeve **50** and hanger body **14**. The handling string is now rotated until lugs **49** are aligned with notches **38** so that body **40** and its sleeve **50** are allowed to descend a distance equal to the depth of notches **38**, bringing the elements to the condition seen in FIG. **5**. Such downward movement causes sleeve **31** to move downwardly relative to body **17** so that, with ring **32** engaging shoulder **28**, packing ring **30** is compressed between ring **32** and sleeve **31** and is forced into good sealing engagement with the wall of the bore of wellhead body **3** as well as with the lower end of sleeve **31** and with ring **32**. Such downward movement of sleeve **50** also drives sleeve **31** downwardly far enough to bring segments **33** into alignment with groove **34**, so that the segments snap outwardly into the groove to secure sleeve **31** in the packing-energizing position seen in FIG. **5**. Simultaneously with energization of the packing, descent of tool body **40** relative to hanger body **14** causes sleeve **46** to engage shoulder **47** so that completion of the downward movement of the tool body causes camming surfaces **45** of latch segments **44** to ride over the upper end of sleeve **46**, with the segments thus being retracted into groove **42**. Sleeve **46** remains in its segment-retracting position by reason of frictional engagement with tool body portion **41** and the tool is thus free to be removed by the handling string, leaving hanger body **14** latched to wellhead body **3**.

Hanger Body Retrieving Tool

Should retrieval of hanger body **14** be necessary, retrieval is accomplished in the manner shown in FIG. **6**, employing a retrieving tool **60** manipulated by handling string **61**. Tool **60** comprises a body **62** the lower end portion of which has an outer diameter such as to be slidably embraced by the wall of the bore of body **17** above shoulder **47**. Body **62** has a transverse annular outwardly opening groove accommodating a plurality of latching segments **63** urged outwardly by springs **64** and having upwardly directed downwardly and outwardly slanting camming surfaces **65**. Above the groove for segments **63**, body **62** presents a right cylindrical outer surface **66** embraced by a segment-retracting sleeve **67**. At the upper end of surface **66**, the outer diameter of body **62** is reduced to provide a transverse annular upwardly directed shoulder **68**.

Tool **60** further includes a generally cup-shaped member **69** having a transverse wall **70** with a central opening embracing body **62** above shoulder **68**, wall **70** being clamped against shoulder **68** by a ring **71** secured in a suitable groove in body **62**, as by screw **72**. The annular wall of member **69** includes a radially thick portion **73**, having an inner diameter such as to slidably embrace sleeve **67**, and a lower end portion **74** which depends from the outer periphery of portion **73** and is identical to sleeve **31***a* in thickness and diameter so that, when the lower end portion of body **62** is inserted downwardly into the bore of body **17**, the end face of portion **74** comes into engagement with the upper end face of sleeve **31***a*. Portion **73** presents a downwardly directed shoulder **75** and portion **74** projects beyond shoulder **75** by a distance such that, as tool **60** is fully landed to bring shoulder **75** into engagement with the upper end face of sleeve **31**, portion **74** projects downwardly sufficiently to force sleeve **31***a* downwardly until segments **33** are fully retracted and hanger body **14** is therefor free for removal from the wellhead. Similarly, the lower portion of body **62** projects below shoulder **75** by a distance such that, when shoulder **75** engages the upper end of sleeve **31**, segments **63** are aligned with and snap outwardly into groove **39** of body **17**, thus securing handling tool **60** to hanger body **14**. Upward withdrawal of the handling string then retrieves the hanger body and its associated seal devices.

Sleeve 67 is fixed to member 69 by shear pin 76 and does not come into play until retrieval of hanger body 14 has been accomplished. A plurality of screws 77 extend downwardly through threaded bores in transverse wall 70 of member 69 and are aligned with sleeve 67. When, during retrieval, tool 60 is raised to the platform or vessel at the surface above the well, screws 77 are operated manually to shear the pins 76 and force sleeve 67 downwardly until segments 63 are fully retracted, and the retrieved hanger body 14 can then be removed from tool 60.

Installation of Firsrt Tubing String

Referring now to FIGS. 7–11, it will be seen that the invention employs for the first-installed tubing string 80 a hanger segment 81 having a flat lateral outer surface portion 82, an upper semi-cylindrical outer surface portion 83 of larger diameter, and a lower semi-cylindrical outer surface portion 84 of smaller diameter, surface portions 83 and 84 being joined by a transverse arcuate downwardly directed shoulder 85. Hanger segment 81 is so dimensioned that shoulder 85 can seat on shoulder 24 of hanger body 14, as seen in FIG. 11, with surfaces 83 and 84 of the segment then being slidably embraced by wall portions 22 and 21, respectively, of the bore of hanger body 14. At each juncture between surface 82 and surface 83, the segment is provided with a straight elongated longitudinally extending groove 86 which opens through the bottom end of the segment and is long enough so that, when shoulder 85 is engaged with shoulder 24, each groove 86 will accommodate the corresponding pair of orienting pins 25.

Segment 81 has a longitudinal through bore, the lower end of which is threaded to accept the threaded end of the uppermost joint of tubing string 80. At an appropriate intermediate point, the through bore includes a transverse annular upwardly facing shoulder 87. Above shoulder 87, the through bore is defined by a wall portion 88, a transverse annular inwardly opening latch groove 89, and an upper wall portion 90. Upper end face 91 of segment 81 slants downwardly toward flat outer surface portion 82.

Hanger element 81 is secured to a handling tool 92 carried by a handling string 93. Tool 92 includes a main body 94, a transverse annular member 95 and an elongated cylindrical tubular body 96. Body 94 includes a portion 97 of larger outer diameter, an upper portion 98 of smaller diameter, and a transverse annular upwardly directed shoulder 99 joining portions 97 and 98. Member 95 is circular, has a cylindrical axial through bore of a diameter of loosely embrace portion 98 of body 94, and has an outer diameter such as to extend across the upper end face of tubular body 96, member 95 being secured to body 96, as by cap screws 100. Body 96 is provided with a transverse annular inwardly opening groove 101, FIGS. 7 and 8, of rectangular radial cross-section. Portion 97 of body 94 has an outwardly opening transverse annular groove 102 so located as to be aligned transverse with grooves 101 when shoulder 99 and member 95 are engaged. The upper and lower walls of groove 102 are frustoconical and converge inwardly. Body 96 includes an outwardly opening recess 103, FIG. 8, which is in the form of a vertically elongated rectangle as viewed in side elevation and which accommodates an orienting member 104 of rectangular configuration, the side, top and bottom walls of recess 103 being slidably engaged respectively with the side, top and bottom surfaces of member 104. Orienting member 104 comprises a main body 105 having a front face 106 and rear face 107. A vertically elongated key 108, formed integrally with body 105, projects from front face 106. A vertical groove 109, FIG. 8, extends completely through body 105 and opens through rear face 107, groove 109 being of rectangular transverse cross-section. Member 104 is completed by a plate 110 which is secured to rear face 107 of body 105, as by screws 111, FIG. 9, and which includes two cylindrical bosses 112 which are spaced apart vertically and which project from plate 110 into groove 109. At the center of the rear wall of recess 103, body 96 is provided with a radial bore 113 communicating between recess 103 and groove 101 and slidably accommodating a transfer member 114. Groove 101 accommodates a resilient metal split ring 115, FIGS. 7 and 8, the dimensions of which are such that, when the ring is relaxed and undistorted, the ring is totally housed in groove 101, no portion of the ring projecting inwardly from body 96. The inner portion of ring 115 has frusto-conical top and bottom walls conforming to the upper and lower walls for groove 102 in portion 97 of body 94. Member 104 is urged outwardly by compression springs 116, FIG. 8.

Body 96 has a vertical through bore 117, FIG. 7, of circular transverse cross-section, the through bore being centered on and therefore interrupted by recess 103. Slidably accommodated in bore 117 is a feeler rod 118 which serves to retain orienting member 104 in a retracted, inactive position until the lower end face of body 96 has been landed on the upper end face of ring 31. Bore 117 opens through the upper end of body 96 but is closed there by member 95. Rod 118 is slightly shorter than bore 117, and a helical compression spring 119 is disposed in the bore between the upper end of the feeler rod and member 95. Over a part of its length which is substantially longer than the height of recess 103, rod 118 is cut away to provide a flat relatively thin portion 120, FIGS. 8 and 10, having two circular ports 121 of a diameter adequate to freely accommodate bosses 112. Ports 121 are spaced apart vertically by the same distance as are bosses 112 and are so located on rod 118 as to register with the bosses only when the bottom end of the feeler rod is at the bottom end of body 96. Portion 120 of rod 118 is located in groove 109 in body 105 of member 104, the arrangement being such that, when bosses 112 are not engaged in ports 121, the feeler rod can move vertically relative to member 104 and, when the ports are registered with the bosses, member 104 can move laterally relative to the feeler rod.

When the tool is assembled in the manner seen in FIG. 7, preparatory to its trip down to the wellhead, feeler rod 118 projects downwardly beyond the lower end of body 96, spring 119 biasing the rod so that shoulder 122, FIG. 10, engages the upper end of body 105. With the feeler rod in that position, ports 121 are out of registry with bosses 112, and member 104 occupies a position in which it is completely housed in recess 103. Thus, key 108 does not project beyond the circumference of body 96 and cannot engage any surrounding part during the trip down. The length of transfer member 114 is such that, with member 104 occupying its innermost or fully housed position, member 114 is forced radially inwardly to shift the split ring 115 to the right, as viewed in FIG. 7. Such shifting causes full engagement of the split ring in groove 102 of body 94 in the location of transfer member 114 and also causes the split ring to contract, so that the balance of the ring is

also engaged in groove **102**. Since the radial thickness of the split ring is substantially greater than the depth of groove **102**, ring **115** is now engaged in both groove **102** and groove **101**, as seen in FIGS. **7** and **8**, and body **94** is therefore locked against axial movement relative to body **96**.

Hanger segment **81** is releasably secured to body **94** of handling tool **92** by a dowel **125**. The upper end portion of dowel **125** is received in a downwardly opening bore **126** in the lower end portion **127** of body **94** and includes a transverse annular groove in which a retaining ring **128** is secured, the ring projecting outwardly from the dowel and being slidably engaged in bore **126**. The lower end of bore **126** is threaded to accommodate the tubular externally threaded shank of a thimble **129** which has a lower end flange **130**. The outer surface of dowel **125** is right cylindrical and of a diameter to be slidably embraced by inner surface portion **88** of segment **81**. The dowel is provided with a transverse annular outwardly opening groove **131** so located that, when the tip of the dowel is engaged with shoulder **87**, groove **131** is aligned with groove **89**. A plurality of latch segments **132** are slidably disposed in groove **131**, are urged outwardly by compression springs (not shown), the latch segments being in accordance with U.S. Pat. No. 3,171,674 to Bickel et al and including downwardly and outwardly slanting upwardly directed camming surfaces **133**. Inner surface portion **90** of segment **81** is of larger diameter than is surface portion **88**, so that an annular space is provided between surface portion **90** and dowel **125** above groove **131**, the latch camming surfaces **133** extending across the annular space when latch segments **132** are engaged in groove **89**. In this space, an actuator sleeve **134** slidably enbraces dowel **125**, the upper end of sleeve **134** engaging flange **130** of thimble **129**, the sleeve being initially fixed to the dowel by shear pins **135**.

The locations of shoulder **87**, groove **89** and groove **131** and the length of dowel **125** and segment **81** are such that, when the tip of the dowel engages shoulder **87** so that latch segments **132** are engaged in groove **89**, sleeve **134** engages both flange **130** and latch segment camming surfaces **133**. Since sleeve **134** is fixed in place by shear pins **135**, thimble **129** is clamped between sleeve **134** and retaining ring **128**. Bore **126** in portion **127** of the tool body extends for a significant distance above ring **128** when the parts are in the positions just described.

Tubular body **96** is provided with a vertical inwardly opening groove **136** which extends for the full length of the inner wall of body **96** and is located diametrically across body **96** from key **108**. Portion **97** of body **94** of the handling tool carries a pin **137** which projects radially from portion **97** in a location immediately below groove **102**. Lower end portion **127** of body **94** has a second downwardly opening bore **138** which is identical to bore **126**, the two bores **126** and **138** being spaced apart diametrically of body **94** so as to be equidistant from the longitudinal axis of body **94**. The longitudinal axes of bores **126**, **138** and the center of pin **137** lie in a common plane which contains the longitudinal axis of body **94**. While tool **92** is being used to land segment **81**, bore **138** is closed by a threaded plug **139**. Body **94** of the handling tool has a central bore **140** which opens through the upper end of the body, so as to communicate with the interior of handling string **93**, and at its lower end comjunicates with both bores **126** and **138**.

To still segment **81** in hanger body **14**, along with tubing string **80**, handling string **93** is manipulated to run the combination of tool **92** and segment **81** down, typically down a riser or an extended casing, until the lower end of feeler rod **118** engages the upper end face of packer sleeve **31**. Throughout the trip down, member **104** is maintained in its fully retracted position by portion **120** of the feeler rod, and ring **115** is therefore engaged both in groove **101** and in groove **102** so that body **94**, carrying the segment **81**, is locked to tubular body **96** in the position seen in FIG. **7**. Once the tip of feeler rod **118** has engaged sleeve **31**, further downward movement of tool **92** causes the combination of body **96** and member **104** to move downwardly relative to feeler rod **118**, such movement continuing until the lower end face of body **96** seats on the upper end face of sleeve **31** as seen in FIG. **7A**. At that point, ports **121** in portion **120** of the feeler rod register with bosses **112** and springs **116** are therefore free to urge member **104** outwardly. Initially, the action of springs **116** is only effective to force key **108** of member **104** into engagement with the wall of the bore of wellhead upper body **7**, but the capability of further outward movement of member **104** persists because both the lower end of the feeler rod and the lower end of body **96** remain engaged with the upper end face of packer sleeve **31**.

Handling string **93** is now manipulated to rotate tool **92** until key **108** registers with the locator groove **53** of body **7**, member **104** then being moved outwardly by springs **116** to cause key **108** to snap into groove **53**. Such outward movement of body **104** allows transfer member **114** to move outwardly, so that split ring **115** relaxes to its undistorted condition, expanding into groove **101** and fully out of engagement in groove **102**. Such action frees body **94** for downward movement within body **96**, but body **94** is restrained against rotation relative to body **96** because of engagement of pin **137** in groove **136**. Handling string **93** is now lowered until shoulder **85** of segment **81** seats on shoulder **24** of hanger body **14**. Since hanger body **14** was oriented by interaction of groove **53** and key **55**, FIGS. **1** and **6**, the rotational position of the hanger body relative to upper wellhead body **7** is predetermined, with orienting pins **25** thus occupying a known position. The location of bore **126** (and thus of hanger segment **81**), groove **136**, pin **137** and key **108** are such that grooves **86** in the hanger segment receive the orienting pins **25** as the segment approaches its fully landed position, and the segment is thus positively located in the intended 180° portion of the bore of hanger body **14**, as shown in FIG. **11**.

Segment **81** having been successfully landed, the segment is released from handling tool **92** by applying downward force on handling string **93** to force the combination of body **94** and thimble **129** to move downwardly relative to dowel **125**. Such movement causes flange **130** of thimble **129** to force actuator sleeve **134** downwardly, so that pins **135** are sheared and the actuator sleeve is moved downwardly against camming surfaces **133** with the result that latch segments **132** are cammed to their retracted positions in groove **131**. Tool **92** can now be withdrawn, leaving segment **81** seated on shoulder **24**. Initial upward movement of handling string **93** causes shoulder **99** of body **94** to reengage member **95**, the entire handling tool **92** then moving upwardly. As key **108** reaches the upper end of groove **53**, member **104** is cammed inwardly so that bosses **112** are withdrawn from ports **121** and feeler rod **118** is thus

freed to be moved downwardly through bore **117** by action of spring **119**. Portion **120** of the feeler rod thus returns to its original position, engaging bosses **112** to hold member **104** retracted. Inward movement of member **104** moves transfer member **114** to force ring **115** again into engagement with groove **102** so that body **94** is locked to body **96**.

Installation of Deflector Plug

With the first segment **81** landed and the handling tool retrieved, the upper end of the segment is exposed to possible damage by the second segment to be landed. To protect segment **81**, a deflector plug, indicated generally at **145**, FIG. **13**, is installed by use of the handling tool **92** previously employed to land hanger segment **81**, dowel **125**, FIG. **7**. having been replaced with a deflector plug dowel **146**. Deflector plug **145** has a cylindrical body **147** having a vertical through bore. The frustoconical lower end surface **148** is dimensioned to engage shoulder **87** of hanger segment **81**. Body **147** carries a plurality of shearable pins **149** dimensioned to be received in groove **89** of the hanger segment, pins **149** being spring biased outwardly and constructed, for example, in accordance with U.S. Pat. No. 3,268,239 to Castor et al so that insertion of the deflector plug downwardly into segment **81** until the plug engages shoulder **87** causes pins **149** to snap into groove **89**. The upper end face **150** of deflector plug **145** is slanted so that, when the deflector plug is properly oriented rotationally and inserted into segment **81**, upper end face **150** of the deflector plug lies in the same plane as end face **91** of the hanger segment. Plug **145** is releasably retained on dowel **146** by shear pins **151**.

Handling tool **92** functions, as described with reference to FIGS. **7–11**, to orient the handling tool rotationally so that deflector plug **145** is aligned vertically with hanger segment **81** and to release body **94** to allow the deflector plug to be landed. Once the deflector plug has been secured in the hanger segment by action of shear pins **149**, the handling tool is retrieved by applying an upward strain on handling string **93**, pins **151** shearing to free dowel **146** from the deflector plug.

Installation of Second Tubing String

As seen in FIG. **14**, the hanger segment **155** from which the second tubing string **156** depends is also installed by means of handling tool **92** and handling string **93**. For this purpose, plug **139**, FIGS. **7** 7A and **11**, is replaced by a thimble **157** which retains a dowel **158** in bore **138**. Dowel **158** is in all respects identical to dowel **125**, FIGS. **7**, 7A and **11**, and serves to secure segment **155** to body **94** of handling tool **92** until, after segment **155** has been landed on shoulder **24** of hanger body **14**, further downward movement of the handling string and handling tool forces sleeve **159** downwardly to cam latch segments **160** inwardly, disengaging the dowel from the segment. Manipulation of the handling tool to orient segment **155** in vertical alignment with its desired position in hanger body **14** is in all respcts the same as hereinbefore described with reference to installation of tubing string **80** and segment **81**.

When hanger segment **155** is secured to the handling tool, dowel **125**, FIG. **7**, is replaced by a retrieving dowel **161**, FIG. **14**, which has an enlarged threaded upper end engaged in the threaded lower end portion of bore **126** in body **94**. The dependent main body **162** of dowel **161** is dimensioned to be slidably accommodated by the through bore of deflector plug body **147**. Orientation of the handling tool **92** by engagement of key **108** in groove **53** aligns dowel **161** vertically with the deflector plug so that, as hanger segment **155** is landed on shoulder **24**, dowel **161** is inserted downwardly through the bore of body **147** of deflector plug **145**. Dowel **161** is of such length as to pass completely through the deflector plug as the handling tool brings segment **155** into engagement with shouler **24**. The lower end portion of body **162** of dowel **161** is slotted to accommodate two dogs **163** which are pivoted on a horizontal pin **164** and biased by a double ended torsion spring **165**. As dowel body **162** enters the bore of the deflector plug, dogs **163** are pivoted upwardly to their retracted positions within the slot in body **162**. When the lower end portion of body **162** passes below the deflector plug, spring **165** pivots dogs **163** downwardly into the laterally projecting positions seen in FIG. **14**, the dogs being stopped in those positions by engagement with the bottom wall of the slot in body **162**.

After latch segments **160** have been disengaged to free dowel **158** from segment **155**, upward movement of handling string **93** and handling tool **92** causes dogs **163** to engage the lower end of deflector plug **145** and continued upward strain on the handling string results in shearing of pins **149** so that deflector plug **145** is retrieved with the handling tool.

Installing Tubing Hanger Packoff Device

FIG. **15** illustrates installation of a tubing hanger packoff device **170** according to the invention, installation being accomplished with a handling tool **92***a* which is secured to handling string **93** and includes all of the elements of handling tool **92**, FIGS. **7**, 7A and **11**, except main body **94**, that element being replaced by a main tool body **171**, FIG. **15**. Packoff device **170** comprises a main body **172** having two vertical through bores **173**, **174** which are spaced apart diametrically of body **172** so that, in one rotational position of body **172** in wellhead upper body **7**, bore **173** will be aligned vertically above segment **81** and bore **174** will be aligned vertically above segment **155**. Bores **173** and **174** are enlarged at their lower ends to accommodate the upper end portions of sleeves **175** and **176**, respectively, those sleeves being welded to body **172**. Sleeve **175** is dimensioned to be received within the upper end portion of segment **81** and is provided with O-rings **177** to seal between sleeve **175** and inner wall portion **90** of segment **81**. Sleeve **176** is similarly dimensioned to be accommodated by the upper end portion of segments **155** and is provided with O-rings **178** to seal with that segment.

Body **172** carries an external seal device, indicated generally at **179**, constructed generally according to U.S. Pat. No. 3,268,241 to Castor et al. At the lower end portion of body **172**, the outer diameter of the body is reduced, presenting a downwardly facing shoulder at **180**. An elastomeric seal ring **181** embraces body **172** below shoulder **180**, and a rigid actuating ring **182** slidably embraces body **172** below seal ring **181**. Actuating ring **182** is initially secured to body **172**, as by shear pins (not shown) in a position such that ring **182** projects well beyond the lower end of body **172**. Above shoulder **180**, body **172** has an outwardly opening transverse annular groove **183** which accommodates a plurality of latching segments **184** biased outwardly by springs (not shown) segments **184** being constructed according to the aforementioned Bickel et al U.S. Pat. No. 3,171,647. Above groove **183**, body **172** is equipped with an actu-

ating sleeve **185** which engages the upwardly directed cam faces of segments **184** to hold the segments in radial positions such that the outer tips of the segments bear lightly on the inner surface of tubular body **96** of the handling tool.

Main tool body **171** has a lower end portion **186** of a diameter such as to be slidably received in the upper end portion of body **172** of the packoff device. Portion **186** carries a plurality of shear pins **187** which are constructed according to the aforementioned Castor et al U.S. Pat. No. 3,268,239, being spring-biased outwardly into engagement with a transverse annular inwardly opening groove **188** in body **172**. Above portion **186**, body **171** is of a diameter to be slidably embraced by the inner wall of tubular body **96**, a downwardly facing shoulder **189** being provided which is in engagement both with the upper end face of body **172** and the upper end of actuating sleeve **185**. The remainder of body **171** is identical with body **94**, FIG. **7**, and presents a transverse annular outwardly opening groove **190** corresponding to groove **102**, FIGS. **7** and **8**, and operative to receive split ring **115** to secure body **171** releasably to tubular body **96**. Immediately below groove **190**, body **171** is equipped with a radially projecting locator pin **191** engaged in groove **136** of member **96**, pin **191** corresponding to pin **137**, FIG. **7**, and being so positioned on body **171** that, when key **108** is engaged in groove **53**, sleeves **175** and **176** are axially aligned respectively with segments **81** and **155**.

Packoff device **170** is installed by manipulating handling string **93** to move the combination of handling tool **92***a* and the packoff device downwardly until the lower end of body **96** engages sleeve **31**, the handling string then being rotated until key **108** snaps into groove **53**, at which point tool body **171** is freed from body **96** so that further descent of the handling string causes sleeves **175** and **176** to enter hanger segments **81** and **155**, respectively, with actuating ring **182** coming into engagement with shoulder **47** of hanger body **17** well before the sleeves are fully inserted in the segments. Continued downward movement of tool body **171** and packoff device **170** causes seal ring **181** to be compressively engaged between actuating ring **182** and shoulder **180**, with the webs of the seal ring being forced outwardly to seal against the surrounding wall presented by body **17**. As packoff device **170** moves into the upper end portion of hanger body **17**, latch segments **184** are cammed inwardly by the chamfer at the inner periphery of the upper end face of body **17**. At a point when seal ring **181** has been fully energized, segments **184** snap outwardly into groove **39** to latch packoff device **170** securely to body **17** of the hanger and thus hold seal ring **181** in its energized condition. With the packoff device thus latched in place, sleeves **175** and **176** are in proper positions within the upper end portions of hanger segments **81** and **155**, respectively. An upward strain on handling string **93** will now cause pins **187** to shear so that tool body **171** can move upwardly within body **96** into engagement with body **95**, and tool **92***a* can then be retrieved.

Packoff device **170** can be retrieved by use of any suitable tool equipped with latching dogs to engage in groove **188** when the tool is landed and so constructed that a part of the tool forces actuating sleeve **185** downwardly to retract segments **184** and thus free the packoff device from the hanger body.

Installation of Circulation Tool

With hanger segments **81**, **155** in place and packoff device **170** installed, it is now necessary to establish communication between each tubing string **80**, **156** and the vessel or platform so that fluid can be circulated through the tubing strings and tubing plugs can be installed. This is accomplished by employing handling tool **92***b* to run in tubular stingers **195** and **196** in the manner illustrated in FIGS. **16** and **16A**.

Tool **92***b* again employs all of the components of tool **92**, FIG. **7**, except for main body **94** which is replaced by a circular main tool body **197**. Body **197** is circular and has flat top and bottom faces **198** and **199** and two vertical through bores **200** and **201**, the through bores being spaced apart diametrically of the body by a distance and in positions such that, when body **197** is properly oriented rotationally in body **96**, and body **96** is oriented by engagement of key **108** in groove **53**, bores **200** and **201** will be coaxially aligned with hanger segments **81** and **155**, respectively. Body **197** has a transverse annular outwardly opening groove **202** which corresponds to groove **102**, FIG. **7**, and accommodates split ring **115** to secure body **197** releasably to body **96**. Orientation of body **197** within body **96** is accomplished by providing body **197** with a locator pin **203** which projects radially from the body and is engaged in groove **136**.

Stingers **195** and **196** are identical, each comprising an intermediate portion **204** having a right cylindrical outer surface slidably embraced by the wall of the respective bore **200**, **201**. Enlargements **205** and **206** are provided respectively above and below body **197** to present shoulders to engage faces **198**, **199**. The upper end of each stinger **195**, **196** is connected to a different one of two tubing strings **207** and **208** which together serve as the handling string for tool **92***b* and which communicate independently with the two stingers. The lower tip portions **209** of each stinger are slotted longitudinally and provided with conventional external "stab threads" to lock into internally threaded portions of hanger segments **81** and **155** at **210** and **211**, respectively, when the stingers are fully inserted in the hanger segments as seen in FIG. **16A**, such thread engagement preventing the stingers from backing out of the segments when pressure is applied to the tubing strings via tubing **207**, **208**.

Operation of tool **92***b* during installation of stingers **195**, **196** is generally the same as hereinbefore described with reference to tools **92** and **92***a*. When tool **92***b* and stingers **195**, **196** are to be retrieved, each handling string **207**, **208** is rotated to release the threaded tip portions of stingers **195**, **196** from the respective hanger segments **81**, **155** and the handling strings are then pulled to remove tool **92***b* with the stingers still secured to the tool.

Installation of Christmas Tree

After tool **92***b* and stingers **195**, **196** have been retrieved, the riser is removed, connector **8** is operated to release from body **3**, and the combination of connector **8** and wellhead upper body **7** is removed. The well is then completed by installing a conventional Christmas tree assembly indicated generally at **215**, FIG. **17**. The tree assembly includes a production upper body **216** equipped with a conventional remotely operated connector **217** for securing body **216** to body **3**. The tree assembly is equipped with guide arms (not shown)

which cooperate with the guide posts of the primary guide system (not shown), so that the tree assembly when landed occupies a known rotational position relative to the guide posts and, therefore, relative to hanger segments **81**, **155**.

Body **216** has two through bores **218**, **219** to communicate respectively with tubing strings **80** and **156** via hanger segments **81**, **155**. Body **216** is equipped with two dependent tubular stingers **220** and **221** each communicating with a different one of bores **218**, **219**. Stingers **220** and **221** are so disposed on body **216** that when body **216** has been oriented by the guide system, movement of the body downwardly into engagement with body **3** causes stingers **220** and **221** first to stab through bores **173** and **174**, respectively, of packoff device **170** and then into hanger segments **81** and **155**.

DETAILED DESCRIPTION OF THE METHOD

From the foregoing description of the apparatus embodiments, it is apparent that groove **53**, FIG. **1**, constitutes a rotational orientation reference, the location of that groove having been determined because the combination of body **7** and connector **8** are precisely positioned by the guide posts at the wellhead. Hanger body **14** is installed in a rotational position predetermined by coaction of key **55** and groove **53**, and the locator pins **25**, which determine the positions to be occupied by tubing hanger segments **81** and **155**, are therefore disposed in predetermined positions relative to groove **53**.

With the first tubing hanger segment **81** secured to the main body **94** of the handling tool in the position determined by bore **126**, FIG. **7**, the main body of the tool is releasably secured to the tubular member **96** of the handling tool by engagement of ring **115** in groove **102**, the rotational position of body **94** relative to key **108** being fixed by engagement of pin **137** in groove **136**. At this stage, feeler rod **118** projects below the lower end of body **96**. Handling string **93** is now manipulated to lower the handling tool until the lower end of body **96** engages sleeve **31**, with the result that rod **118** is forced to its uppermost position and key body **104** is therefore released so as to be capable of moving outwardly under the force applied by springs **116**. The handling string is now rotated until key **108** snaps outwardly into groove **53**. Such coaction of the key and groove causes segment **81** to be aligned coaxially with its respective portion of the bore of of hanger body **14** and also causes ring **115** to disengage from groove **102**, releasing body **94** from body **96**. The handling string is then manipulated to lower body **94** and hanger segment **81** until the hanger segment lands in its predetermined rotational position on shoulder **24** of the hanger body. During this step, locator pin **137** remains engaged in groove **136** and, of course, key **108** remains engaged in groove **53**, so that proper orientation of body **94** and segment **81** is preserved until the segment is landed. As the segment approaches shoulder **24**, locator pins **25** engage in the half-grooves or flutes **86** of the segment to finalize location of the segment.

A final increment of downward movement of the handling string and body **94** is then effective to force actuator sleeve **134** downwardly within segment **81** to force segments **132** inwardly, releasing dowel **125** from the segment, and the combination of the handling string and body **94** is pulled until body **94** engages body **95**. Further withdrawal of the handling string raises the entire handling tool, so that key **108** reaches the upper end of groove **53** and is cammed inwardly, causing bosses **112** to be withdrawn from ports **121**, FIG. **10**, to free feeler rod **118** to be moved downwardly relative to body **96** by spring **119**. Such downward movement of the feeler rod locks member **104** in its retracted position and locks ring **115** again in groove **102**, so that body **94** is again secured to body **96**. The entire handling tool is now retrieved by pulling the handling string.

With the handling tool again at the vessel or platform, dowel **125** is replaced by dowel **146**, FIG. **13**, carrying the deflector plug **145**, and the method repeated for installation of the deflector plug in hanger segment **81**. The handling tool is then retrieved and used again to install the second hanger segment **155** and tubing string **156**, after which the handling tool is again retrieved. Body **94** is then replaced by body **171**, FIG. **15**, the method is repeated for installation of the tubing hanger packoff device **170**, and the handling tool again recovered. Body **171** is then replaced by body **197**, FIG. **16**, and the method is repeated, using tubing strings **207** and **208** as the handling string, for installation and ultimate retrieval of circulation stingers **195** and **196**. After retrieval of the handling tool and stingers **195**, **196**, the Christmas tree is installed conventionally.

What is claimed is:

1. In the completion of a mutiple string underwater well installation of the type comprising a generally tubular support structure located under water above the well bore and including rotational orientation reference means, the improvement comprising

installing in the tubular support structure a multiple string tubing hanger body constructed and arranged to support at least two tubing hanger segments each occupying a predetermined position witin the hanger body,

said step of installing the hanger body being carried out in a manner which locates the hanger body in a predetermined rotational position relative to the rotational orientation reference means;

providing a handling tool having

a main body connected to a handling string,

a tubular body surrounding the main body and extending therebelow, and

locator means carried by the tubular body and operative to coact with the orientation reference means of the support structure;

releasably securing the main body of the handling tool to the tubular body of the handling tool in the same rotational orientation relative to the locator means of the handling tool as the hanger body occupies relative to the orientation reference means;

releasably securing the hanger segment of a first tubing string to the main body of the handling tool;

manipulating the handling string to lower the handling tool and the first tubing string under the locator means of the handling tool is in a position to coact with the orientation reference means;

rotating the handling string to rotate the handling tool until the locator means coacts with the orientation reference means;

releasing the main body of the handling tool from the tubular body of the handling tool;

lowering the main body of the handling tool through the tubular body of the handling tool, while preventing rotation of the main body relative to the tubular body, until the hanger segment of the first tubing string has landed in the hanger body;

releasing the main body of the handling tool from the hanger segment of the first tubing string;
retrieving the handling tool;
again releasably securing the main body of the handling tool to the tubular body of the handling tool in said same rotational orientation;
releasably securing the hanger segment of a second tubing string to the main body of the handling tool;
again lowering the handling tool an again rotating the handling tool until the locator means coacts with the orientation reference means;
again releasing the main body of the handling tool from the tubular body of the handling tool and lowering the main body through the tubular body, while preventing rotation of the main body relative to the tubular body, until the hanger segment of the second tubing string has landed in the hanger body;
releasing the hanger segment of the second tubing string from the main body of the handling tool; and
retrieving the handling tool.

2. The method according to claim **1**, further comprising

connecting to the main body of the handling tool, after retrieving the handling tool following installation of the first tubing string, a deflector plug constructed and arranged for installation in the hanger segment of the first tubing string,

the deflector plug being connected to the main body of the handling tool in the same position which was occupied by the hanger segment of the first tubing string;

manipulating the handling string to lower the handling tool and deflector plug until the locator means of the handling tool is in a position to coact with the orientation reference means;

rotating the handling string to rotate the handling tool until the locator means coacts with the orientation reference means;

releasing the main body of the handling tool from the tubular body of the handling tool;

lowering the main body of the handling tool through the tubular body of the handling tool, while preventing rotation of the main body relative to the tubular body, until the deflector plug has landed in the hanger segment of the first tubing string;

releasing the main body of the handling tool from the deflector plug; and

retrieving the handling tool and then installing the hanger segment of the second tubing string by carrying out the steps recited in claim **1**.

3. The method according to claim **2**, further comprising

reconnecting the deflector plug to the main body of the handling tool simultaneously with landing of the hanger segment for the second tubing string; and

retrieving the deflector plug with the handling tool when the handling tool is next retrieved.

4. The method according to claim **1**, further comprising

providing a tubing hanger packoff device including a body having two through bores to communicate respectively with the hanger segments of the first and second tubing strings when the packoff device has been installed in the tubular support structure;

replacing the main body of the handling tool with a second main body adapted to be releasably connected to the packoff device;

connecting the packoff device to the second main body and releasably connecting the second main body to the tubular body of the handling tool in the same rotational orientation relative to the locator means of the handling tool as the hanger body occupies relative to the orientation reference means;

manipulating the handling string to lower the handling tool and packoff device until the locator means is in a position to coact with the orientation reference means;

rotating the handling string to rotate the handling tool until the locator means coacts with the orientation reference means;

releasing the second main body of the handling tool from the tubular body of the handling tool;

lowering the second main body of the handling tool through the tubular body of the handling tool, while preventing rotation of the second main body relative to the tubular body, until the packoff device has been landed;

releasing the handling tool from the packoff device; and

retrieving the handling tool.

5. The method according to claim **4**, further comprising

replacing the second main body of the handling tool with a third main body having two through bores spaced apart by the same distance as the hanger segments of the first and second tubing string are spaced in the hanger body;

removing the handling string;

installing two tubular stingers each in a different one of the through bores of the third main body;

connecting the upper ends of the stingers each to a different one of two handling tubing strings;

releasably connecting the third main body of the handling tool to the tubular body of the handling tool in the same rotational orientation relative to the locator means of the handling tool as the hanger body occupies relative to the orientation reference means;

manipulating the two handling tubing strings to lower the handling tool and stingers until the locator means is in a position to coact with the orientation reference means;

rotating the handling tool, by manipulating the two handling tubing strings, until the locator means of the handling tool coacts with the orientation reference means;

releasing the third main body of the handling tool from the tubular body of the handling tool;

lowering the third main body of the handling tool through the tubular body of the handling tool, while preventing rotation of the third main body relative to the tubular body, until the stingers have been inserted into operative positions in the hanger segments;

carrying out operations in the well bore by circulating fluid through the handling tubing strings and the stingers; and

retrieving the handling tool and stingers.

6. The method for remotely installing multiple tubing strings independently in an underwater well installation, comprising

establishing in an underwater location above the well bore a tubular support structure including a tubing hanger body and rotational orientation means lo-

cated above the tubing hanger with the tubing hanger body defining specific locations for at least two tubing hanger segments and occupying a predetermined rotational position relative to the rotational orientation means;

connecting a handling tool main body to a handling string at an operational base above the underwater location;

releasably connecting the handling tool main body to a handling tool tubular body equipped with locator means constructed and arranged to coact with the rotational orientation means;

releasably connecting the hanger segment of a first tubing string to the handling tool main body with the hanger segment depending from the handling tool main body in a position such that rotation of the handling tool can bring the hanger segment into vertical alignment above its intended specific location in the tubing hanger body;

manipulating the handling string to lower the handling tool to a position in which the hanger segment is above the hanger body and the locator means can coact with the rotational orientation means;

manipulating the handling string to rotate the combination of the handling tool and the hanger segment until the locator means coacts with the rotational orientation means;

releasing the handling tool main body from the handling tool tubular body in response to coaction of the locator means with the rotational orientation means;

lowering the handling tool main body through the handling tool tubular body, while preventing rotation of the main body relative to the tubular body, and thereby landing the hanger segment in its intended specific location in the hanger body;

releasing the hanger segment from the handling tool; and

retrieving the handling tool preparatory to using the handling tool to install the hanger segment for the second tubing string.

7. In a handling tool for remotely installing a device with specific rotational orientation in an underwater well installation of the type having a tubular support structure located under water and provided with rotational orientation reference means disposed above the location at which the device being installed is to be landed, the combination of

a main body adapted to be connected to at least one handling string in such manner that the at least one handling string can be manipulated to rotate the main body about its central axis, the main body having

a circular outer surface, and

means for connecting to the main body at least one device to be installed, with the connected device depending from the main body;

a tubular body surrounding the main body and equipped with externally exposed locator means constructed and arranged to coact with the rotational orientation reference means of the underwater tubular support means;

releasable means for securing the main body to the tubular body,

the main body being free to be moved downwardly through the tubular body when the releasable means has been released; and

locator means coacting between the main body and the tubular body for maintaining the main body in a predetermined rotational position relative to the externally exposed locator means when the main body is secured to the tubular member and while the main body is moved through the tubular member.

8. The combination defined in claim **7**, wherein

the releasable means is constructed and arranged to release the main body for downward movement through the tubular body in response to coaction of the externally exposed locator means with the rotational orientation reference means.

9. The combination defined in claim **8**, wherein

the rotational orientation reference means is a vertical inwardly opening groove;

the externally exposed locator means is a key carried by the tubular member for movement between a recessed position and an outwardly projecting position,

the key being resiliently biased outwardly to snap into the vertical groove when rotation of the handling tool causes the key to register with the groove; and

the releasable means comprises

an outwardly opening recess in the main body,

a retaining member carried by the tubular body and normally occupying an outwardly displaced inactive position, and

means operated by the key for forcing the retaining member into the recess when the key is in its recessed position.

10. The combination defined in claim **9**, wherein

the outwardly opening recess in the main body is a transverse annular groove; and

the retaining member is a resilient split ring disposed in an inwardly opening transverse annular groove in the tubular member,

the split ring being contracted into engagement in the outwardly opening groove as a result of movement of the key inwardly to its recessed position.

11. The combination defined in claim **9**, wherein

the lower end of the tubular member is dimensioned to engage a predetermined element in the tubular support structure and thus limit downward movement of the tubular member;

the combination further comprising

a vertical feeler rod carried by the tubular element and movable between a first position, in which the feeler rod extends below the lower end of the tubular member, and a second position, in which the feeler rod is displaced upwardly from its first position; and

means operated by the feeler rod for locking the key in its recessed position when the feeler rod is in its first position and releasing the key for outward movement only when the feeler rod is in its second position.

12. The combination defined in claim **7**, wherein

the locator means coacting between the main body and the tubular body comprises

a vertical groove on one of the bodies, and

a locator member carried by the other of the bodies and projecting into the vertical groove.

13. The combination defined in claim **7**, wherein

the main body has a downwardly opening bore located in the lower end thereof and spaced from the

central axis of the main body by a distance equal to that by which the device to be installed is to be spaced from the central axis of the tubular support structure when the device is properly landed; and

the means for connecting at least one device to be installed comprises

a dowel retained in the downwardly opening bore and depending from the main body, and

means carried by the dowel for releasably securing the device to be installed to the dowel.

14. The combination defined in claim **13**, wherein

the device to be installed is the tubing hanger segment of a first tubing string, the segment having a through bore and a transverse annular inwardly opening groove;

the dowel carries a plurality of latching segments mounted for movement between a recessed position and an outwardly projecting latching position,

the latching segments being resiliently biased outwardly, disposed to engage in the inwardly opening groove of the hanger segment when the dowel is inserted into the hanger segment, and provided with upwardly directed camming surfaces which are exposed at the periphery of the dowel when the segments are in their latching position;

a segment retracting sleeve slidably embraces the dowel between the segments and the main body; and

the main body can be moved downwardly relative to the dowel to cause the segment retracting sleeve to move downwardly against the camming surfaces of the latching segments to retract the latching segments and thus release the hanger segment from the dowel after the hanger segment has been landed in the hanger body.

15. The combination defined in claim **13**, wherein

the main body has a second downwardly opening bore spaced from the central axis of the main body by a distance equal to that by which a second device to be installed is to be spaced from the central axis of the tubular support structure when the second device is properly landed, whereby the handling tool can be employed for installing both the first and second device.

16. The combination defined in claim **15**, wherein

both of said downwardly opening bores are of the same diameter and each is internally threaded;

an externally threaded thimble is engaged in said first mentioned bore,

said thimble being shorter than the bore in which it is engaged,

said dowel being slidably embraced by said thimble and extending thereabove,

the upper end portion of said dowel having a transverse enlargement engaged over the upper end of the thimble to retain the dowel.

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